



Verified Carbon Standard

A VERRA STANDARD

SUSTAINABLE AGRICULTURAL PRACTICES FOR CARBON SEQUESTRATION BY ORGANIC AND NATURAL FARMING GROUPS

Document Prepared by



Contact Information

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1 PROJECT DETAILS

1.1 Summary Description of the Project

Soil carbon is an important attribute of soil quality and its productivity. Doran and Parkin (1994) defined soil quality as the capacity of a soil to function, within ecosystem boundaries, to sustain biological productivity, improve environmental quality and support human and plant health.

Soil quality cannot be measured directly but inferred indirectly by measuring soil physical and chemical properties, which serve as quality indicators (Diack and Stott 2001). One-third of the global soils are degraded, releasing 78 gigatons (Gt/year) of carbon-di-oxide into the atmosphere, which cost over 10% of the global GDP through lost biodiversity and ecosystem services (FAO 2019). Thus, reversing soil degradation is vital to feed a growing global population, protect biodiversity and help address the climate crisis. Soil Organic Carbon (SOC) content, being an energy source for soil biota, is a critical determinant of land degradation neutrality, agricultural productivity and climate change adaptation and mitigation. However, Indian soils are low in SOC in the top layer (0.2 meters). Enhancing SOC in agricultural soils has great potential to contribute to climate mitigation while also promoting soil health and resilience.

Karnataka is considered as a miniature of India as it exhibits most of the features of India in terms of climate, soil types, rainfall, crops grown, and a variety of natural resources. The proposed 'Sustainable Agricultural Practices for carbon Sequestration by Organic and Natural farming groups' activity implemented by Vedic Green Solutions (VGS), includes the participation of about 29,739 farmers associated with organic grower cooperatives covering 57,516 hectares of cropland in the state of Karnataka to be implemented in the first phase. The project aims at increasing the capacity of soil to sequester carbon, enhance the carbon sequestration by agroforestry practices such as planting of trees and avoiding emissions from use of synthetic fertilizers by application of VCS methodology: VM0017 Sustainable Agricultural Land Management (SALM). Several SALM practices and technologies have been proven to reduce greenhouse gas emissions and prevent climate change by enhancing carbon storage in soils; preserving and improving the existing soil carbon; and promoting carbon dioxide sequestration and reducing nitrous oxide emissions. Some of those practices are use of organic fertilizers, residue retention, agroforestry practices and avoidance of use of chemical fertilizers. The project holistically aims at implementing these sustainable management practices which improves soil health, reduces greenhouse gas (GHG) emissions of the project area. The project aims to reduce and sequester carbon leading to an estimated annual GHG emission reductions or removals of 171,399 tCO_{2e} throughout its lifetime. This project's climate benefits include emissions reduction or removals of approximately

5,141,971(tCO₂e)(Five million, one hundred forty-one thousand, nine hundred and seventy-one.) over the lifetime of the project.

1.2 Sectoral Scope and Project Type

The sectoral scope of the project activity corresponds to VCS scope 14 “Agriculture, Forestry and Other Land Use” (AFOLU) and under the category “Agriculture Land Management” (ALM). Eligible ALM activities are those that reduce net GHG emissions on croplands and grasslands by increasing carbon stocks in soils and woody biomass and/or decreasing CO₂, N₂O and/or CH₄ emissions from soils. In the ALM category, this project falls under the following activity group:

Improved Cropland Management (ICM): This category includes practices that demonstrably reduce net GHG emissions of cropland systems by increasing soil carbon stocks, reducing soil N₂O emissions, and/or reducing CH₄ emissions. Among this, the proposed project focuses on

- a) Practices that increase soil carbon stocks by increasing residue inputs to soils and/or reducing soil carbon mineralization rates, use of cover crops, enhanced crop rotations and introduction of agroforestry practices.

The project is a grouped project as described in the VCS Standard v4.3, 2022, as a project structured to allow the expansion of the project activity subsequent to validation. Validation is based upon the initial project activity instances identified in the project description. The project description sets out the geographic areas within which new project activity instances may be developed and the eligibility criteria for their inclusion. New instances meeting these pre-established criteria may then be added to the project subsequent to project validation. During the project implementation, an increasing number of new farms are expected to adopt SALM practices. Therefore, the project will include further project activity instances (farms) subsequent to initial validation of the project. The initial instances comprise of 29,739 farmers, who implement SALM and improved livestock management on their farms – totaling to about 57,516 hectares.

1.3 Project Eligibility

The Project is eligible under the scope of VCS Programme as described below:

- The VCS Program provides the standard and framework for independent validation of projects and programs, and verification of GHG emission reductions and removals, based on ISO 14064-2:2019 and ISO 14064-3:2019. The scope of the VCS Program covers all those activities related to the generation of GHG emission reductions and removals, including jurisdictional programs and nested REDD+ projects.
- Project Proponent uses the criteria listed in the section 2.1.1 of the VCS standard, v4.3.

- The project activity is suitable to the application of the Approved VCS methodology VM0017: Adoption of Sustainable Agricultural Land Management (version 1.0), which is approved under the VCS Program through the methodology approval process.

Further, the project is eligible under the scope of the VCS standard v4.3 as summarised below:

- This is an eligible AFOLU project category under the VCS Program related to Agricultural Land Management Practices (ALM)
- The project applies a methodology eligible and approved under the VCS Program
- The implementation of this project activity is in line with the applicable law of the host country.
- This project does not convert native ecosystems to generate GHG reductions. The project area only contains cropland or degraded land for a minimum of 10 years before the project start date.
- This project does not occur on wetlands and does not drain native ecosystems or degrade hydrological functions.
- The project establishes additionality by use of AR-TOOL02 Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities, version 1.0
- Non-permanence risk was analyzed in accordance with the VCS Program document AFOLU Non-Permanence Risk Tool, Version 4.0.

1.4 Project Design

- The proposed project is a group project.

The project activity accelerates climate neutrality through market mechanisms, providing expertise to value native vegetation and encourage reforestation through various training and awareness programs, encourage farmers to adopt best agricultural practices, agro-forestry systems from time to time, dissemination of knowledge gain from Remote Sensing/GIS study on existing status of organic carbon content in the participants' land and recommendations to members on carbon fixation in the soil through various steps from time to time, rewarding farmers for their contribution to nature preservation.

Eligibility criteria

The project is a group project. The eligibility criterion for the addition of new instances is as follows:

Table 1: Eligibility criteria for addition of instances to the grouped project

No	Eligibility criterion – Category	Eligibility criteria and how it will be met at the time of inclusion.
1	Geographic Boundary	The geographical boundary of the new instance must be within the State of Karnataka. Detailed documentation regarding the exact geographical location such as GPS coordinates will be provided.
2	Ownership	Similar criteria as stated in the section 1.7 of the VCS PD will be applicable, based on which the relevant new areas will be included in the project. For the ownership of the project. i.e., solely for the 'Rights of access to the Carbon Credits' – a participation agreement has been established between the cooperative societies of which the farmers are members and the project proponent (VGS) declaring that the carbon credits generated by the implementation of the project activity, is exclusively allocated to the developer of the Project. Under this agreement, the farmer associations will be provided with a share of proceeds related to the carbon credit sale by an equitable sharing mechanism. Further it will be verified that the instance (individual farm) adopting the project activity belongs to the individual farmer and the status of land is private land and there are no existing disputes. The legal title of the land parcels is held with individual farmers and is indicated through the land records available with the local authority (Tahsildars) of the Karnataka state which will be verified.
3	Approval and authorization	Approval and authorization as mentioned from time-to-time will be applicable for all the instances. The current requirements applicable for the instances added in this verification are mentioned in section 1.7 of the VCS PD.
4	Double Counting	Emission reductions claimed by each of the instances under the grouped project should be unique and not counted more than once. The unique geographical location can be cross verified which will ensure that there is no double counting. The same will also be verified through Undertaking from the PP confirming that instance is not an individual project or part of any other grouped project.

5	Start Date	Date on which activities conforming to the definition of start date as per VCS requirements in the instance were started, which shall be after start date of the grouped project. The start date of the project in line with the VCS requirements is October 1 st , 2017.
6	Applicability of the methodologies	The version of methodology VM0017 version 1.0 and its associated tools shall be applicable.
7	Additionality	Criteria as specified in the current joint validation and verification document section 3.5 (PD-MR) shall be met
8.	Classification of land cover types	Criteria as specified in the current joint validation and verification document section 1.12 (PD-MR) shall be met
9.	Baseline scenario establishment	Criteria as specified in the current joint validation and verification document (PD-MR) section 3.4 shall be met
10.	Quantification of GHG emission	Criteria as specified in the current joint validation and verification document (PD-MR) section 4 shall be met
11.	Monitoring of GHG removals	Criteria as specified in the current joint validation and verification document (PD-MR) section 5 shall be met
12	Soil Organic Carbon (SOC) modelling for future instances	<p>This methodology is applicable to projects that introduce sustainable agriculture land management practices (SALM) into an agricultural landscape subject to the following conditions: (VM0017 - Adoption of Sustainable Agricultural Land Management, version 1.0, Section I.2):</p> <p>a. Land is either cropland or grassland at the start of the project.</p> <p>SALM activities are implemented within the individual farmlands of registered farmers, and no SALM project activity will be implemented on forest land. The project is not converting native ecosystems to either cropland or grassland. Considering that SALM activities are implemented within the individual farms on cropland and grassland, no project activity will be implemented on forest land. To prove that a farm area is cropland, we used the Sentinel-2 10-Meter Land Use/Land Cover¹.</p>

¹ <https://livingatlas.arcgis.com/landcoverexplorer/>

		<p>The cultivated areas under SALM are clearly defined and demarcated. During the periodic baseline and monitoring surveys, these areas are randomly checked and verified as cropland.</p> <p>b. The new project does not occur on wetlands.</p> <p>The total project area and the farms of the first project instance do not occur on wetlands, following the definition of wetlands according to the 2003 IPCC GPG LULUCF² guidance where a wetland category “includes land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories”. Furthermore, as said before, the project is implemented within the individual farmlands of registered farmers and no SALM project activity will be implemented on wetlands.</p> <p>c. The land is degraded and will continue to be degraded or continue to degrade.</p> <p>The excessive and improper use of chemical fertilizers is globally recognized as a significant contributor to soil degradation and diminished fertility over time. Historical trends, including data from the Desertification and Land Degradation Atlas³ for 2011-2013, indicate that 36.24% of land in Karnataka is undergoing degradation. This decline in soil fertility is largely attributed to unsustainable agricultural practices, and, in the absence of corrective measures, this trend is expected to continue further degrading farmland. The direct consequence of reduced soil fertility is a decrease in crop yields, posing a serious threat to food security in the region.</p> <p>d. The area of land under cultivation in the region is constant or increasing in the absence of the project.</p> <p>The area under crop land has shown a constant trend of increase in the project area. According to National</p>
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² https://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf

³ https://vedas.sac.gov.in/static/atlas/dsm/Desertification_Atlas_2016_SAC_ISRO.pdf

		<p>Remote Sensing Centre, ISRO, Hyderabad⁴ land use land cover data for the years 2005-06 and 2015-16, the area under cultivation follows an increasing trend in the project area. (Figure 1 and Figure 2).</p> <p>e. Forest land, as defined by the national CDM forest definition, in the region is constant or decreasing over time.</p> <p>A 2016 geospatial study by TV Ramachandra et al⁵. highlighted significant changes in the forest cover of Karnataka's Central Western Ghats, a region with the state's highest forest density. The study revealed a decline in evergreen and semi-evergreen forest cover from 57.31% in 1979 to 32.08% in 2013. Additionally, interior forests decreased from 64.42% to 25.62% over the same period, while non-forest areas such as croplands, plantations, and built-up areas increased to 47.29%. These findings indicate a clear trend for forest cover reduction in the region.</p> <p>f. There must be studies (for example: scientific journals, university theses, local research studies or work carried out by the project proponent) that demonstrate that</p> <p>the use of the Roth-C model is appropriate for: (a) the IPCC climatic regions of 2006 IPCC AFOLU Guidelines, or (b) the agroecological zone (AEZ) in which the project is situated.</p> <p>For the SALM project we have selected the IPCC climatic zone. According to IPCC climate regions, the project activity instances fall under Tropical dry, Tropical moist and Tropical dry climate zone⁶. The following studies have been selected to demonstrate that the application of the RothC model is appropriate and that the model is validated for similar IPCC climatic zone. The study "Simulating change in soil organic carbon in two long term fertilizer experiments in India: with the RothC</p>
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⁴ <https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php>

⁵ <https://forestecosyst.springeropen.com/articles/10.1186/s40663-016-0069-4>

⁶ <https://philipaudebert.users.earthengine.app/view/ipcc-climate-zones>

		<p>model" published by Bhattacharyya et al. in 2013⁷, aimed to assess the impact of different long-term fertilizer treatments on soil organic carbon (SOC) in two agricultural experimental sites in India. The researchers used the RothC model to simulate changes in SOC stocks in response to different fertilizer treatments, including organic and inorganic amendments. The study found that the RothC model accurately predicted changes in SOC stocks in response to different fertilizer treatments, demonstrating the model's applicability and effectiveness in predicting SOC changes in long-term agricultural experiments in India.</p> <p>Another relevant study, "Simulating Soil Organic Carbon Stock Under Different Climate Change Scenarios: A RothC Model Application to Typical Land-Use Systems of Goa, India" by Paramesh et al⁸., explored the effect of climate change on SOC stocks across different land-use systems in Goa. This research highlights the influence of varying environmental conditions on soil health and carbon storage, underscoring the RothC model's value for sustainable land management and climate resilience. These studies validate the model's relevance and application to the project's climatic and ecological context.</p> <p>2. Deploy the SALM technologies or measures specified in the project description and apply the technologies or measures in the same manner as specified in the project description – see section 1.11 .</p> <p>The eligibility conditions outlined above shall be assessed for modeling Soil Organic Carbon (SOC) in future instances.</p>
13	Comply with at least one complete set of eligibility criteria for the inclusion of new project	The eligible instances to be included in the project activity will apply the same measures (sustainable

⁷https://www.researchgate.net/publication/274546754_Simulating_change_in_soil_organic_carbon_in_two_long_term_fertilizer_experiments_in_India_with_the_Roth_C_model

⁸ <https://www.sciencedirect.com/science/article/abs/pii/S0341816222001151>

	activity instances as per VCS Standard	agricultural ,land management practices) as described in the project description.
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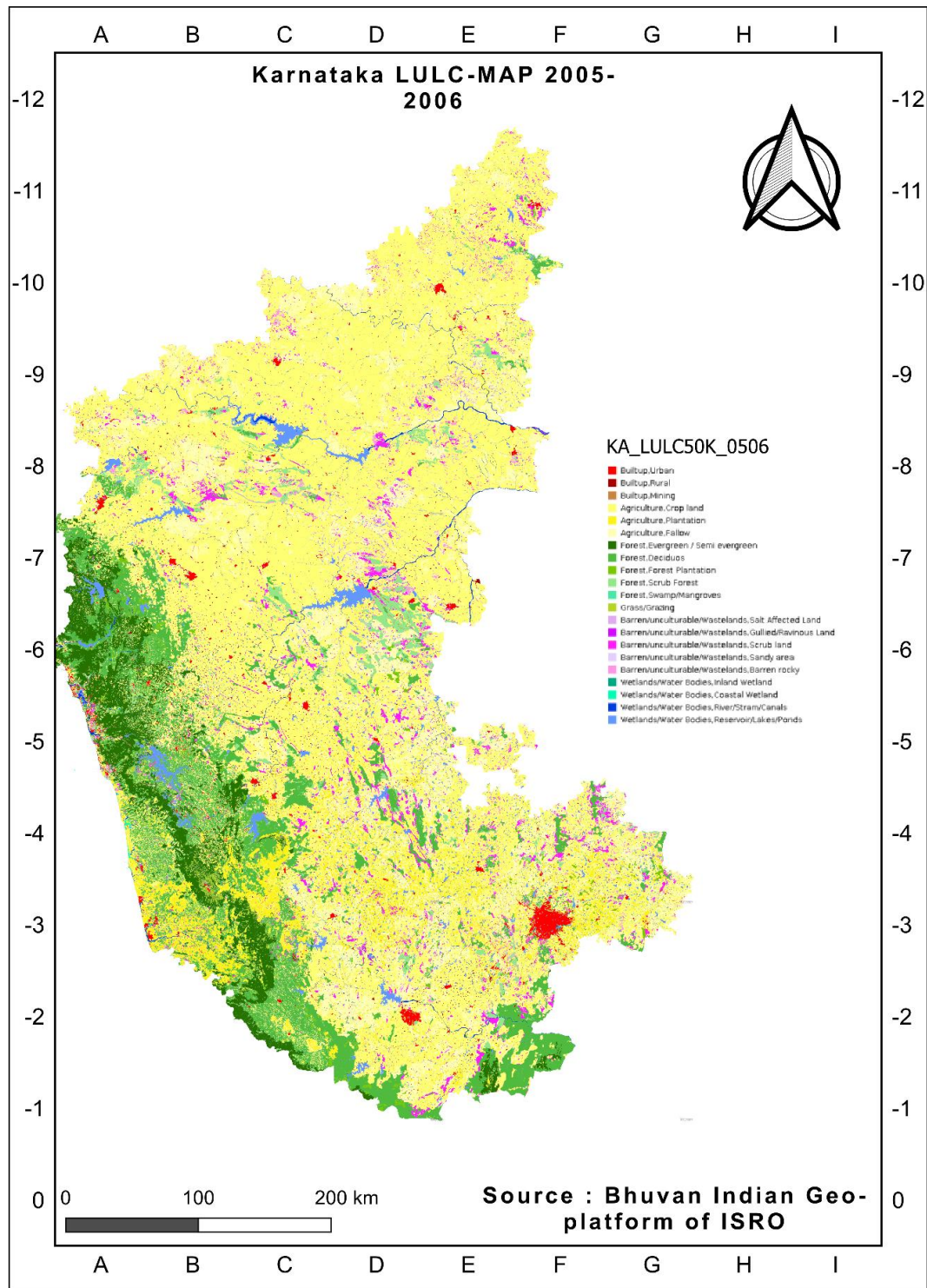


Figure 1: 2005-2006 Land use land cover map of Karnataka

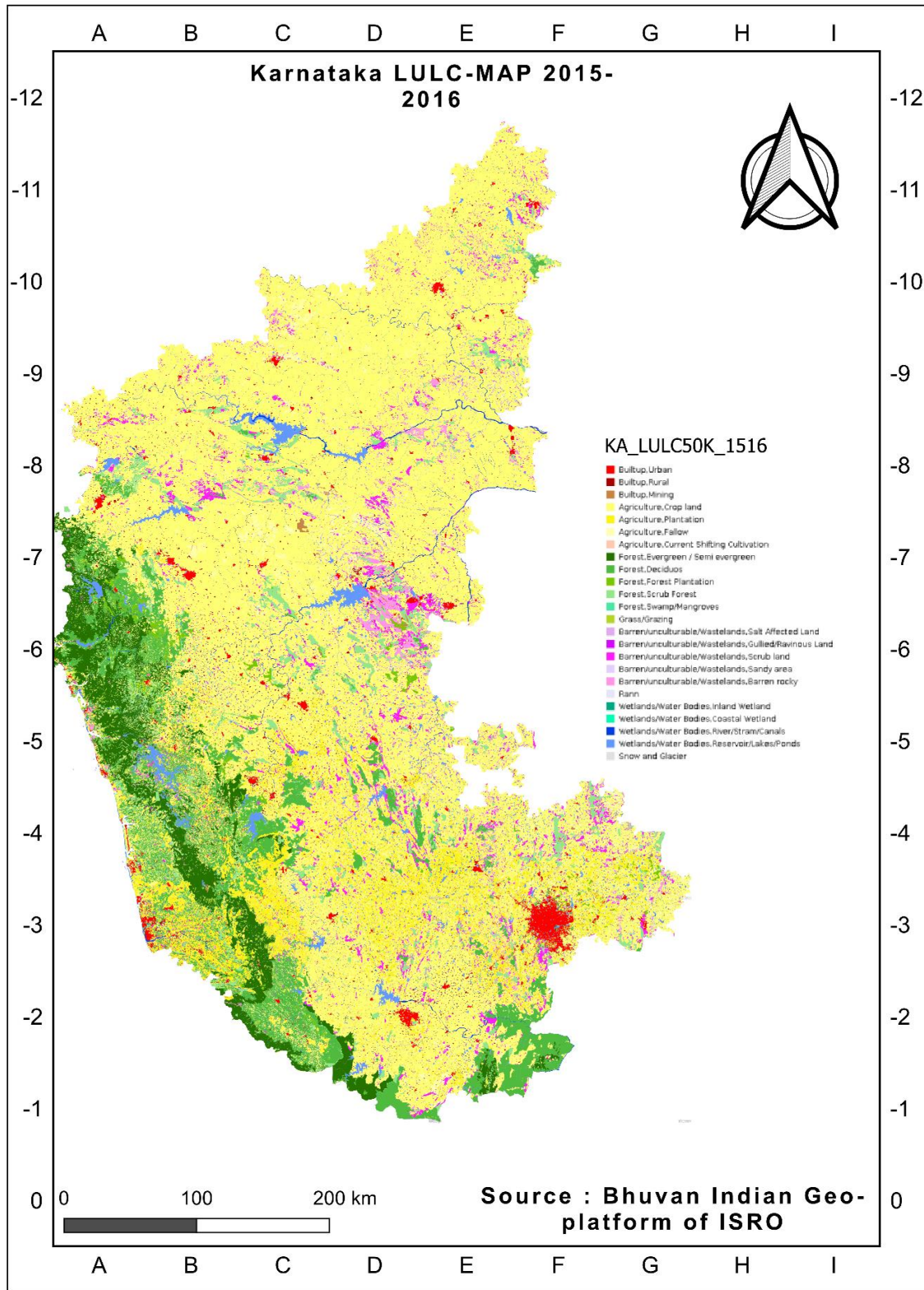


Figure 2: – 2015-2016 Land use land cover map of Karnataka

The project instances are spread across the IPCC climatic zones. Karnataka is divided into 3 IPCC climatic zones taking into consideration the rainfall pattern-quantum and distribution, soil types, texture, depth and physio-chemical properties, elevation, topography major crops and type of vegetation. IPCC climatic zones and their characteristics are summarized in the Table below as published by Govt. of India (Directorate of Economics and Statistics, 2013).

Table 2 : Classification of IPCC climatic zones according to crop types

Zone code	IPCC climatic zone	Zone name	Districts covered	Climate	Topography and major crops
KA-1	Tropical dry	Northeast transition zone	Bidar	Tropical monsoon, semi-arid	Predominantly grown kharif crops. The soils are shallow to medium black, clay in major areas and lateritic in the remaining areas. The important crops grown are pulses, jowar, oilseeds, bajra, cotton, and sugarcane.
KA-2	Tropical dry	Northeast dry zone	Gulbarga, Raichur, Yadgir	Semi-arid (wetter half)	Predominantly grown rabi crops. The soils are deep to very deep black clay in major areas and shallow to medium black in minor pockets. The principal crops grown are rabi jowar, bajra, pulses, oilseeds, and cotton.
KA-3	Tropical dry	Northern dry zone	Bagalkot, Bellary, Bijapur, Gadag, Koppal	Semi-arid	Predominantly grown rabi crops. Soils are shallow to deep black clays in major areas. The important crops grown are rabi jowar, maize, bajra, groundnut, cotton, wheat, sugarcane, and tobacco.
KA-4	Tropical dry	Central dry zone	Chikmagalur, Chitradurga, Davangere, Kodagu	Semi-arid (wetter half)	Predominantly grown kharif crops. Soil is red sandy loam in major areas, shallow to deep black in the remaining areas. The principal crops grown are ragi, rice, jowar, pulses, and oilseeds.
KA-5	Tropical dry	Eastern dry zone	Bangalore R, Bangalore U, Chikballapur, Kolar, Ramanagara, Tumkur	Semi-arid	Predominantly grown kharif crops. Red loamy soil in major areas, and lateritic in the remaining areas. Main crops are ragi, rice, pulses, maize, mulberry, and oilseeds.
KA-6	Tropical dry	Southern dry zone	Chamarajanagar, Hassan, Mandya, Mysore	Semi-arid to dry sub-humid	Predominantly grown kharif crops. The soil is red sandy loam in major areas and black soil in pockets of the remaining areas. The principal crops grown are

					rice, ragi, pulses, other millets, and sugarcane.
KA-7	Tropical moist	Southern transition zone	Shimoga	Semi-arid	Predominantly grown kharif crops. Soil is red sandy loam in major areas and red loamy in the remaining areas. The principal crops grown are rice, ragi, pulses, jowar, and tobacco.
KA-8	Tropical dry	Northern transition zone	Belgaum, Dharwad, Haveri	Semi-arid and arid	Predominantly grown kharif crops, found shallow to medium black clay soil and red sandy loam soil in equal proportion. The main crops grown are rice, jowar, groundnut, pulses, sugarcane, and tobacco.
KA-9	Tropical moist	Hill zone	U. Kannada	Per humid	The soil is red clay loam in major areas. The principal crops are rice and pulses.
KA-10	Tropical wet	Coastal Zone	D. Kannada, Udupi	Dry sub-humid and per humid	The soils are red lateritic and coastal alluvial. The crops grown are rice, pulses, and sugarcane.

Source. Directorate of Economics and Statistics (2013).

Note. Bangalore R = Bangalore Rural; Bangalore U = Bangalore Urban; U Kannada = Uttara Kannada; D Kannada = Dakshina Kannada.

Cropping patterns are influenced by IPCC climatic zones and hence this is considered as the basis for stratification. IPCC climatic zones have several positive impacts on agriculture, including:

Improved crop selection: IPCC climatic zones help in identifying the crops that are best suited for a particular region, based on the prevailing climate and soil conditions. This helps farmers in selecting the most appropriate crops for their fields, which can lead to improved crop yields and productivity.

Sustainable farming practices: By identifying the crops that are best suited for a particular zone, farmers can use appropriate cultivation techniques, such as crop rotation, intercropping, and soil conservation practices, to maintain the fertility of the soil and prevent environmental degradation.

Better resource allocation: The identification of IPCC climatic zones can help in better allocation of resources, such as water, fertilizers, and pesticides, by providing a clear understanding of the specific needs of crops in each zone.

Improved food security: IPCC climatic zones can help in ensuring food security by promoting the cultivation of crops that are best suited for a particular region and reducing the reliance on food imports.
Reduced environmental impact: By promoting sustainable farming practices and reducing the use of chemical inputs, IPCC climatic zonation can help in reducing the environmental impact of agriculture, such as soil degradation and water pollution.

Overall, IPCC climatic zonation has several positive impacts on agriculture, which can lead to improved crop yields, sustainable farming practices, and reduced environmental impact.

The data sheets (farm diaries) are submitted to the VVB, which indicate that all the SALM activities included under this project are carried out across all the farms in all the strata. Hence as the full monitored data sets are available, the calculations for the fertilizer application rates and the agroforestry removals were based on the field data from the farm diary.

As per the methodological requirements, stratification is applied for the input parameters related to soil modelling such as baseline ($t = 0$) values for SOC stocks, crop productivity and the amount of residue returned to the soil for the different strata (IPCC climatic zone). IPCC climatic zone has the major influence on the soil organic carbon and hence this is considered as the basis for stratification.

According to the conditions for applying RothC model to SOC estimations, there must be studies (for example, scientific journals, university theses, local research studies or work carried out by the project proponents) that demonstrate that the use of the Roth C model is appropriate for: (a) the IPCC climatic regions of 2006 IPCC AFOLU Guidelines, or (b) the agro-ecological zone (AEZ) in which the project is situated.

According to IPCC climate regions⁹, the project activity instance is in tropical dry climate zone. The following studies have been selected to demonstrate that the application of the RothC model is appropriate and that the model is validated for similar IPCC climate regions.

Simulating Soil Organic Carbon Stock Under Different Climate Change Scenarios: A RothC Model Application to Typical Land-Use Systems of Goa, India" (Paramesh et al., 2022): This research assessed the effects of climate change on SOC stocks across various land-use systems in Goa, India, which spans the Tropical Wet and Tropical Moist zones ¹⁰. Hence the applicability condition is met.¹¹

Bhattacharya, et al. (2011)¹² - This study analysed the effect of land use management including manure application on total organic content of soil in Indore district of Madhya Pradesh state, India. Application of RothC model in this study revealed that supplement of organic materials coupled with fertilizers can increase the SOC sequestration. Hence the applicability condition is met.

1.5 Project Proponent

Organization name	Vedic Green Solutions
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⁹ <https://www.ipcc-nggip.iges.or.jp/public/2019rf/corrigenda1.html>

¹⁰ IPCC Climate Zones

¹¹ <https://www.sciencedirect.com/science/article/abs/pii/S034181622001151>

¹² Bhattacharyya, T., et al. "Evaluation of RothC model using four Long Term Fertilizer Experiments in black soils, India." Agriculture, ecosystems & environment 144.1 (2011): 222-234.

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1.6 Other Entities Involved in the Project

Organization name	NA
Role in the project	NA
Contact person	NA
Title	NA
Address	NA
Telephone	NA
Email	NA

1.7 Ownership

Land Ownership:

The land a parcel adopting the project activity belongs to the individual farmers and the status of land is private land. The legal title of the land parcels is held with individual farmers and is indicated through the land certificate records available with the local authority (Tahsildars) of the Karnataka state. The information can also be accessed through the online portal <https://landrecords.karnataka.gov.in>.

Project Ownership

For the ownership of the project. i.e., solely for the ‘Rights of access to the Carbon Credits’ – a participation agreement has been established between the cooperative societies of which the farmers are members and the project proponent (VGS) declaring that the carbon credits generated by the implementation of the project activity, is exclusively allocated to the developer of the Project. Under this agreement, the farmer associations will be provided a share of proceeds related to the carbon credit sale by an equitable sharing mechanism.

Besides, the project proponent commits to support farmers community, to pursue best agricultural practices, contributing to efficient use of natural resources and low-carbon production and enhanced carbon sequestration

1.8 Project Start Date

Project start date is 01.10.2017. Based on VCS requirements, the start date is based on the initiation of the implementation of SALM practices in the farm level. The earliest date of the farmer associations adopting the practice of SALM and signing the agreement with the project developer is hence considered as the appropriate start date. The evidence has been provided to the VVB.

1.9 Project Crediting Period

Project start date	01.10.2017
Project end date	30.09.2047
Total no. of. Crediting years	Total of 30 years (renewable twice)

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

The scale of the project and estimated GHG emission reductions/removals for 30 years are shown in the table below:

- <20,000 tCO₂e/year

- 20,000 – 100,000 tCO₂e/year
- 100,001 – 1,000,000 tCO₂e/year
- >1,000,000 tCO₂e/year

Project Scale	
Project	X
Large project	

Estimated GHG emission reduction or removal (tCO₂e) project activity lifetime is summarised as below

Year	Estimated net GHG emission reductions or removals
	(tCO ₂ e)
2017*	28,276
2018	114,015
2019	117,673
2020	124,832
2021	135,997
2022	151,567
2023	165,261
2024	166,407
2025	167,571
2026	168,754
2027	169,956
2028	171,177
2029	172,417
2030	173,676
2031	174,954
2032	176,252
2033	177,568
2034	178,904
2035	180,259
2036	181,634
2037	183,028
2038	184,442

2039	185,875
2040	187,329
2041	188,802
2042	190,294
2043	191,807
2044	193,340
2045	194,893
2046	196,466
2047**	148,544
Total estimated ERs	5,141,971
Total number of crediting years	30
Average annual ERs	171,399

**From Oct. to Dec 2017, ** up to Sept 2047*

1.11 Description of the Project Activity

The purpose of this project is to promote SALM practices for mitigation of degraded lands and greenhouse gas emission and build adaptive capacity of farmers to be able to the impacts of climate change. Therefore, the project propagates social, economic and environmental benefits that arise from implementation of the activities.

The proposed 'Sustainable Agricultural Practices for carbon Sequestration by Organic and Natural farming groups' activity implemented by Vedic Green Solutions (VGS), includes the participation of about 29,739 farmers associated with organic grower cooperatives covering 57,516 hectares of cropland in the state of Karnataka to be implemented in the first phase. Capacity building for the farmers, training them on the methods to increase soil organic carbon, appointing expert consultants in soil and organic farming to conduct period camps and soil testing, and providing enhanced market access to organic fertilizers. The following table illustrates the IPCC climatic zone¹³ wise area covered for the implementation of these sustainable agricultural practices. It is also declared that the project is not located within a jurisdiction covered by a jurisdictional REDD+ program.

¹³ <https://philipaudebert.users.earthengine.app/view/ipcc-climate-zones>

Table 3: Farmer and area classification based on IPCC climatic zone

IPCC Zone	Soil Order	No. of Farmers	Area (ha)	Total area (ha)
Tropical Dry	Alfisols	9,878	16,578	47,134
	Aridisols	580	911	
	Entisols	5,701	14,073	
	Inceptisols	6,133	10,687	
	Ultisols	198	489	
	Vertisols	1,925	4,396	
Tropical Moist	Alfisols	2,592	5,210	9,419
	Entisols	449	914	
	Inceptisols	1,617	2,869	
	Ultisols	32	50	
	Vertisols	190	376	
Tropical Wet	Alfisols	195	411	963
	Entisols	42	126	
	Inceptisols	102	234	
	Ultisols	89	154	
	Vertisols	16	38	
Total		29,739	57,516	57,516

Methodology

A soil carbon project aims to help farmers manage their soils and enhance soil carbon level in a more sustainable and profitable manner. Soil sampling and testing provides an estimate about the soil nutrition, health and soil carbon level. An increase in measured soil carbon benefits the farmers through more productivity. VGS promotes the following SALM activities among the farming communities to enhance soil fertility and crop productivity.

SALM Project activities

Use of Organic Fertilizer

Organic agriculture has a particular sequestration potential as it follows the key principle of tight nutrient and energy cycles through organic matter management in soils. This is achieved through improved practices in cropland management and in agro-forestry. Various long-term trials provide evidence that the regular addition of organic materials to the soil is the only way to maintain or even increase soil organic carbon (SOC). The systematic development and application of organic fertilization technologies has been the domain of Organic Agriculture for many decades and outstanding results have been achieved so far. Key issues of technological development have been:

1. To optimize the quantity and application of organic manure. A close integration of crop production and animal husbandry and the systematic recycling of organic waste are basic elements.
2. To improve organic waste processing techniques to obtain high quality manure. Through composting animal and plant residues losses in the humification process are minimized and a higher proportion of the solid humus fraction is achieved.

In the study area, different kinds of organic manures like farmyard manure, compost and green manure (Crop residue) were used. Based on the cropping systems, the application rates are recommended (based on studies by Agricultural Development and Rural Transformation Centre, 2015). The average recommended rate is around 3 tons / hectare for farmyard manure and for the other types of the average recommended rate is around 0.4 tons / hectare. However, due to the high subsidies associated with the use of chemical fertilizers, it is seldom observed these recommended rates are applied. Hence the project endeavors to encourage farmers to apply the recommended organic fertilizer application rates to ensure the effectiveness of SALM practices.

Crop residues refer to the plant materials left in the field after harvesting and before the next sowing season. Crop residues is used for feeding livestock, both in the baseline as well as in under project implementation These include stalks, stubble (stems), leaves, roots, and seed pods. Farmers often utilize these residues as mulch by evenly spreading them across the soil surface, or by establishing trash lines along the contours using materials like millet, maize, and sorghum stalks, grasses, litter, and other dead organic matter.

These practices help in:

- Reducing surface runoff and controlling soil erosion
- Enhancing water infiltration
- Improving soil moisture retention
- Suppressing weed growth and pest populations
- Contributing to soil organic matter and nutrient levels

Importantly, burning crop residues is discouraged as it destroys beneficial soil organisms (e.g., earthworms and microbes) and releases greenhouse gases and particulates into the atmosphere. Although many of these practices are most associated with organic farming, they are recommended management practices for all farms because they build soil organic matter, which has far reached benefits for plant health and farm sustainability. These practices minimize biota disturbance and erosion losses while incorporating carbon rich amendments and retaining the biomass of roots and shoots, all of which contribute to carbon sequestration by photosynthetic removal and retention of atmospheric carbon dioxide in soil organic matter. These

practices result from management decisions regarding cropping, amendments and tillage within the wider scope of a systems approach to farming that rejects synthetic inputs. Further, the avoidance of emissions from use of synthetic fertilizers is accounted for in this SALM practice with periodic field monitoring.

Enhancement of Soil Organic Carbon:

The use of organic fertilizers in the soil is expected to increase the Soil Organic Carbon (SOC), which is calculated by use of modeling approach as stipulated by the methodology. Since SOC is having the largest contribution in carbon pool among the terrestrial ecosystem, which is estimated to be over 1550 Pg C at 1m soil depth. Considering the potential of the soil ecosystem to store carbon, it is attracting considerable attention to curb the issues of climate change in the near future. The practices of agroforestry involving the minimal disturbance of soil and continuous cover of litter help in stabilizing the soil organic and enhancing the overall increase in SOC.

Sequestration by Agroforestry:

Agroforestry is a management system that integrates trees in the agricultural landscape. It holds the biggest potential for agricultural carbon sequestration in tropical countries. The soil-based ecosystem services in agroforestry are carbon transformation, nutrient cycling, regulation of soil erosion, soil structure maintenance, symbiotic interactions, enhancement of soil microclimate. The practices of agroforestry help to improve the soil physio-chemical and biological properties by continuous addition of litter in the soil surface. Further, the sequestration of carbon by agroforestry practices is quantified by periodic field monitoring according to the methodology requirements.

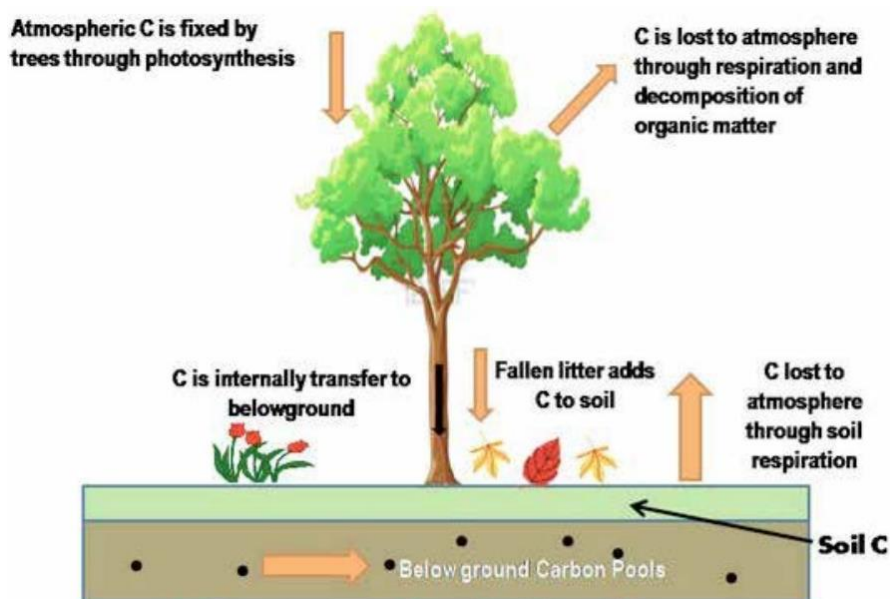


Figure 3: Carbon sequestration process in an agroforestry sytem (adapted from Ram Newaj et al.51)

Some of the predominant agroforestry tree species planted in the districts are summarised in the table below.

Table 4: Agroforestry species planted in the project area

District	Predominant species				
Bagalakote	<i>Pongamia pinnata</i>	<i>Albizia amara</i>	<i>Azadirachta indica</i>	Guava	Mango
Bangalore Rural		<i>Azadirachta indica</i>	<i>Pongamia pinnata</i>	Tamarind	Mango
Bangalore Urbon	<i>Azadirachta indica</i>		<i>Melia dubia</i>	Guava	Sapota
Belgaum	<i>Azadirachta indica</i>	<i>Melia dubia</i>	<i>Grevillea robusta</i>	Jack fruit	Jambolan
Bellary	<i>Pongamia pinnata</i>	<i>Azadirachta indica</i>	<i>Albizia amara</i>	Mango	Guava
Bidar	<i>Azadirachta indica</i>	<i>Ficus religiosa</i>		Tamarind	Jambolan
Chamarajnagar	<i>Grevillea robusta</i>	<i>Ficus religiosa</i>	<i>Azadirachta indica</i>	Jack fruit	Sapota
Chickmagaluru	<i>Grevillea robusta</i>	<i>Azadirachta indica</i>	fish-tail palm	Jack fruit	Fig
Chikkaballapura		<i>Melia dubia</i>	<i>Azadirachta indica</i>	Tamarind	Mango
Chithradurga	<i>Azadirachta indica</i>	<i>Aegle marmelos</i>	<i>Melia dubia</i>	Guava	Sapota
Dakshina Kannada	<i>Aegle marmelos</i>	<i>Azadirachta indica</i>	<i>Grevillea robusta</i>	Jack fruit	Jambolan
Davangere	<i>Ficus religiosa</i>	<i>Azadirachta indica</i>		Tamarind	Guava
Dharwad	<i>Melia dubia</i>	<i>Azadirachta indica</i>	<i>Albizia amara</i>	Mango	Jambolan
Gadag		<i>Azadirachta indica</i>	<i>Aegle marmelos</i>	Guava	Jambolan
Hassan	fish-tail palm	<i>Azadirachta indica</i>	<i>Albizia amara</i>	Jack fruit	Jambolan
Haveri	<i>Pongamia pinnata</i>	<i>Melia dubia</i>	<i>Azadirachta indica</i>	Jack fruit	Sapota
Kalaburgi	<i>Grevillea robusta</i>		<i>Azadirachta indica</i>	Sapota	Jambolan
Kodagu	<i>Aegle marmelos</i>	fish-tail palm	<i>Azadirachta indica</i>	Jack fruit	Fig

Kolar	<i>Melia dubia</i>	<i>Azadirachta indica</i>	<i>Grevillea robusta</i>	Mango	Tamarind
Koppala	<i>Azadirachta indica</i>	<i>Aegle marmelos</i>	<i>Ficus religiosa</i>	Mango	Sapota
Mandya	<i>Pongamia pinnata</i>	<i>Azadirachta indica</i>		Jack fruit	Jambolan
Mysore	<i>Azadirachta indica</i>		<i>Melia dubia</i>	Jack fruit	Fig
Raichur	<i>Aegle marmelos</i>	<i>Azadirachta indica</i>		Jack fruit	Sapota
Ramanagara		<i>Azadirachta indica</i>	<i>Grevillea robusta</i>	Mango	Guava
Shimoga	<i>Azadirachta indica</i>	<i>Grevillea robusta</i>	<i>Albizia amara</i>	Jack fruit	Jambolan
Tumkur	<i>Pongamia pinnata</i>	<i>Azadirachta indica</i>		Tamarind	Sapota
Udupi	<i>Melia dubia</i>	<i>Azadirachta indica</i>	<i>Grevillea robusta</i>	Jack fruit	Mango
Uttara Kannada	<i>Aegle marmelos</i>	<i>Melia dubia</i>	<i>Azadirachta indica</i>	Jack fruit	Fig
Vijayapura	<i>Azadirachta indica</i>		<i>Albizia amara</i>	Jack fruit	Jambolan

Project management for SALM practices:

Project management for Organic fertilizers application

In the project area, different kinds of organic manures like farmyard manure, compost and green manure (Plant residue) were used. Based on the cropping systems, the application rates are recommended (based on studies by Agricultural Development and Rural Transformation Centre, 2015). The average recommended rate is around 3 tons / hectare for farmyard manure. For the other types of the average recommended rate is around 0.4 tons / hectare. However, due to the high subsidies provided by the Government associated with the use of chemical fertilizers, it is seldom observed these recommended rates are applied by the farmers due to which the overall usage rate of organic fertilizers is very low. Hence the project endeavors to encourage farmers to apply the recommended organic fertilizer application rates to ensure the effectiveness of SALM practices.

Project management for Agroforestry

According to FAO, for agroforestry systems, a spacing of 4m between trees is recommended. considering a 4m x 4m spacing in semi-arid tropics which would translate to an estimated 1250 trees that can be planted in 1 hectare for block plantations. This spacing is also indicated by the Guideline for farm forestry for private lands (November 2012), published by JICA which recommended tree density of 400 -1600 trees per hectare for block plantation and 200 trees per hectare for bund plantation.

According to a review paper in the Annals of Forest Science by Morhart et.al. (2014) studies done by Dupraz and Liagre (2008) indicate that trees should not be planted too closely on the tree line and recommend distances between 4 and 10 m depending on the expected tree canopy size of mature trees. Using optimal spacing as described above, high annual diameter increments of 1 cm per year can be achieved (Spiecker 2006). Adequate spacing of trees ensures that tree canopies do not close or shade each other; this minimizes dead branches and the potential for fungal infection (Oosterbaan et al.2009). Nevertheless, the initial tree density is comparable with other agroforestry systems and should be as low

as possible consistent with a final density of 50 to 80 mature trees per hectare (Balandier and Dupraz 1998).

As explained in “Woody plants in agro-ecosystems of semi-arid regions (Bremner, H. & J.J. Kessler, 1996. Advanced Series in Agricultural Sciences 23. Springer-Verlag, Berlin. 340 p.), what counts is the total cover of the tree crowns and the annual biomass that is produced for soil improvement. The optimum found is a cover of 20 – 25%, ensuring that the trees are homogeneously distributed and that the crowns are high in the sky, ensuring a thin and homogeneous shadow. The key factor through which the tree improves crop production appears to be indirect, by improving the fields’ soil organic matter status. This leads to a significant improvement of the water and nutrient capacity of the soil; the crop benefits also.

Although there is no specific guidance of trees planted per hectare for Agroforestry systems (Agri – horticulture – silviculture / boundary planting and scattered planting), the objective of the project is to plant followed a planting density of 8-10 trees / farm / year with spacing of 3m between the trees (considering the average area of the farm is 0.8 to 1 hectare). The project expects to achieve a crown cover of 30% per farm, in the next 7-8 years¹⁴.

1.12 Project Location

The project area which is the Karnataka State is situated between 11°47’32.8” N and 18°16’3.24” N latitude and 76°43’22.93” E and 77°17’50.65” E longitude in the center of western peninsular India. For the administrative purpose the State is divided into 31 districts, which are subdivided into 227 taluks (Figure 4). The physical features of the state include coastal plains, Western Ghats and plateaus enabling it to grow a variety of crops.

¹⁴ <https://empri.karnataka.gov.in/storage/pdf-files/CCC/2019-Krishi%20Aranya%20Prothsaha%20Yojane-A%20case%20Study.pdf>

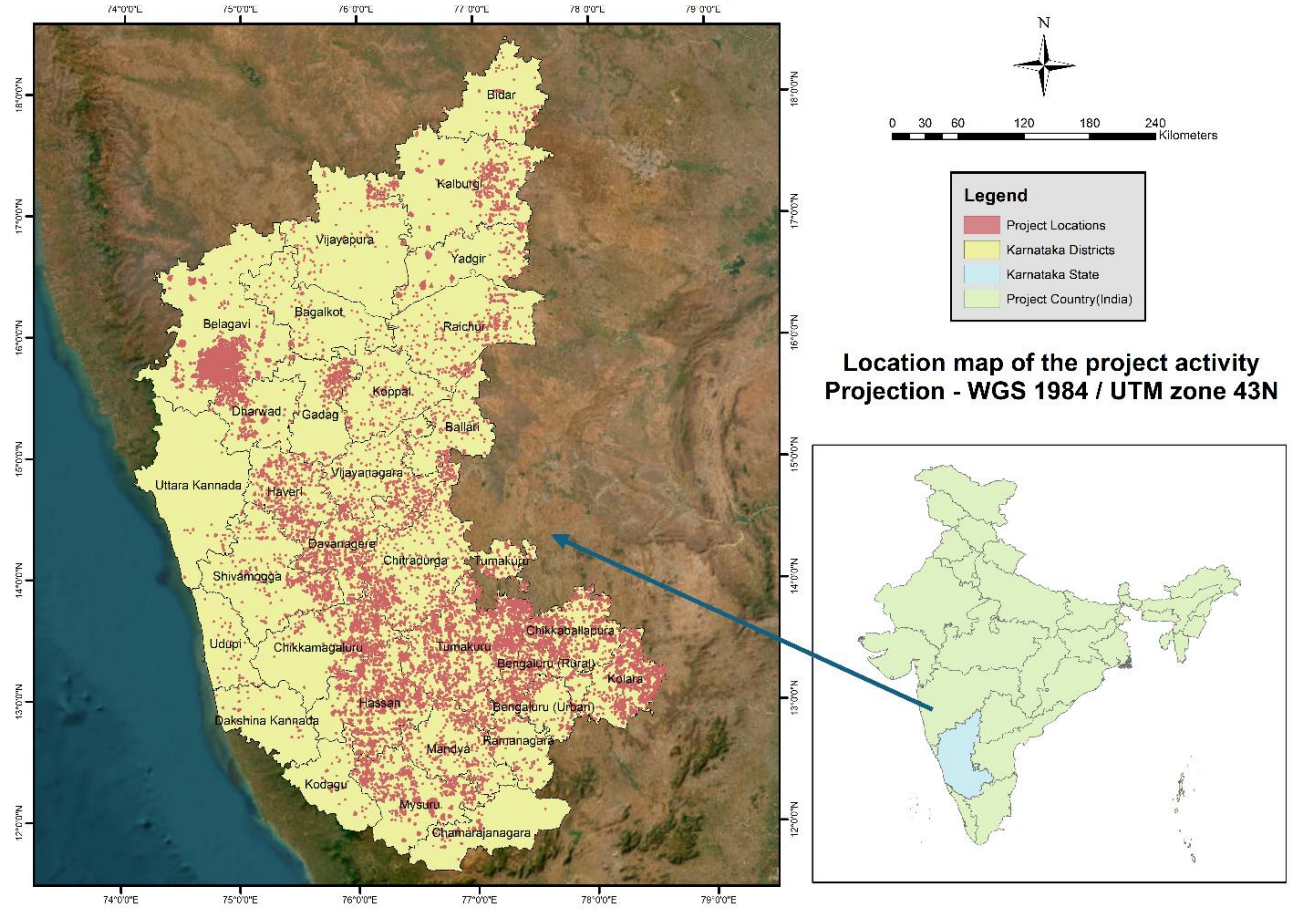


Figure 4: Location map of the project activity

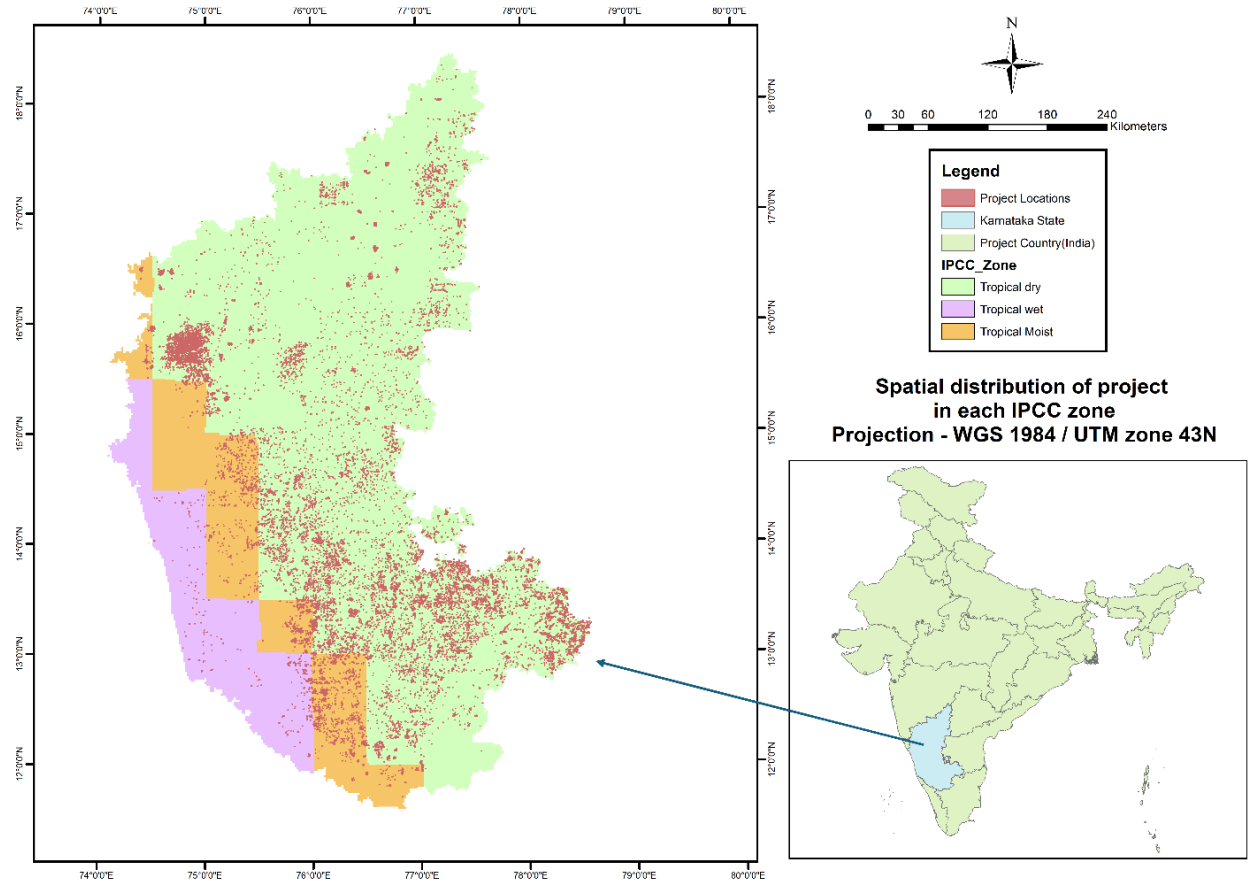


Figure 5 : Spatial distribution of project location

1.13 Conditions Prior to Project Initiation

The baseline scenario of the project area is the same as the conditions existing prior to the project initiation.

Increase in use of chemical fertilizers:

The main crops grown in Karnataka are Rice, Ragi, Jowar (sorghum), maize, and pulses (Tur and gram) in addition to oilseeds and several other cash crops. Cashews, coconut, cardamom, chilies, cotton, sugarcane, and tobacco are also produced. The Kharif crops in Karnataka comprise millets, paddy (rice), maize, moong (pulses), groundnut, red chilies, cotton, soybean, sugarcane, rice, and turmeric. Great millet, wheat, Maize, Cotton, Bajra, Chilies, Onion, and Groundnut are the major crops grown in Rabi season.

According to the Agriculture policy report in 2015, organic fertilizer potential has not been fully utilized as the government has given high incentive especially in the form of heavy subsidy for using chemical fertilizers. Only three chemicals- NPK (nitrogen, phosphorus and potassium) are

heavily subsidized. Plants require at least 17 elements for their growth. The ratio of NPK usage should be 4:2:1 but due to excess usage this is not followed. Urea is cheap to purchase so farmers use it more that creates imbalance due to which the yield either decreases or is stagnant. Over usage of fertilizer is a bigger challenge than subsidy. In the 1950s, with the use of less NPK, the yield was more. Now, with the use of more NPK, lesser yield is being produced. Hence there is a need to improve the organic content of the soil through organic farming or compost. Instead of giving subsidies on chemicals, it is very important to incentivize those farmers who are practicing organic farming and encourage them. Ultimately, these subsidies will only help fertilizer companies to sustain their business but in the long run farmer's business will be hampered because his input costs will continuously increase with inversely proportional output rates. The product is also not safe for consumption. Subsidies should be linked to productivity which will encourage farmers to use more organic fertilizers.

According to a study by ICAR in 2014, the organic content in the soil in India had decreased to 0.3 to 0.4 % which is well below the acceptable limit and is a cause for concern. Though farmyard manure and organic manure are being used it is not prevalent, and most farmers are not aware of the long-term benefits.

Expansion in irrigated areas and coverage of high-yielding varieties resulted in higher demand and the use of chemical fertilizers in Karnataka. Total fertilizer consumption increased to 21.1 lakh tons by 2010-11 as against 12.5 lakh tons during 2001-02 (Summarized in **Figure 6** as below). Consumption of phosphatic and potassic fertilizers was relatively higher when compared to nitrogenous fertilizers. The use of fertilizers increased from 103 kg per hectare in 2001-02 to 162 kg per ha during 2010-11. (Agricultural Development and Rural Transformation Centre, 2013).

Year	Fertilizers used per hectare				Nutrient wise consumption			
	(In Kgs)				(In Lakh tonnes)			
	N	P	K	TOTAL	N	P	K	TOTAL
1991-92	30.1	23.6	13.4	67.1	4.5	2.9	1.7	9.1
2001-02	52.4	29.8	18	103.3	6.7	3.6	2.2	12.5
2005-06	58	33	26	117	7.5	4.4	3.4	15.3
2010-11	78	53	30	162	10.2	7	4	21.1

Source: GOK, Statistical Abstract of Karnataka, various issues

Figure 6: Usage rate of fertilizers

Increase in land use conversion to cropland:

Agroforestry is not commonly practised as the forest cover in the State. A geospatial study in 2016 (TV Ramachandra et.al, 2016) showed the regions in Karnataka having the highest forest cover in the state such as Central Western Ghats has been experiencing changes in its forest cover and consequent alterations in functional abilities of its ecosystem. Temporal land use analyses show the trend of deforestation, evident from the reduction of evergreen -semi evergreen forest cover from 57.31% (1979) to 32.08% (2013) Forest fragmentation at the landscape level shows a decline of interior forests 64.42% (1979) to 25.62% (2013) and transition of non-forest categories such as crop land, plantations and built-up areas, amounting now to 47.29%. Hence there is a decreasing trend of forest cover.

LULC study by Raza and Handa (2020) based on 2015 satellite data mapped the agroforestry areas in Karnataka. As observed in the table below the Agroforestry systems contribute to only around 7.22%. If block plantation is excluded (usually not practised by small scale farmers), the agroforestry cover, corresponding to an average tree cover of 30-40% covers is much lesser. Hence the adoption of boundary plantation and agri -silviculture / agri – horticulture practices which is one of the objectives of this SALM project becomes important.

Agroforestry systems	Tree cover (%)	Estimated area (ha)			
		Coconut only	Supari only	Coconut + supari	Others species
Scattered trees/ boundary plantation	20-29	3690.43	3471.90	7459.55	9190.71
	30-39	4083.44	3511.81	10935.19	9132.42
Agri-silviculture/ agri-horticulture system	40-49	4286.94	3567.40	12989.26	8969.18
	50-59	4371.84	3587.33	13881.54	8274.30
Block plantation	60-69	3910.75	3066.45	14020.88	7743.97
	70-79	3507.78	1776.10	13622.28	6242.46
	80-89	3045.66	0	12796.01	3233.89
	90-100	9996.65	0	16559.37	22941.73
Agroforestry area (ha)		36893.49	18192.90	102264.08	76516.76
Percentage (%)		3.48	1.72	9.63	7.22

Figure 7: Agroforestry systems prevalent in India (adapted from Raza and Handa, 2020)

Topography

Karnataka is comprised of varied topographical structures that include high mountains, plateaus, residual hills and coastal plains. The State is enclosed by chains of mountains to its west, east and south. It consists mainly of plateaus which have higher elevation of 600 to 900 meters above mean sea level. The entire landscape is undulating, broken up by mountains and deep ravines. Plain land of elevation less than 300 meters above mean sea level is found only in the narrow coastal belt, facing the Arabian Sea. There are quite a few high peaks both in Western Ghat systems with altitudes more than 1,500 meters. A series of cross-sections drawn from west to east across the Western Ghat generally exhibit, a narrow coastal plain followed to the east by small and short plateaus at different altitudes, then suddenly rising to great heights. Then follows the gentle east and east-north-west sloping plateau.

Soils

The main soil types of Karnataka State are:

Red Soils which are shallow to deep, well drained to excessively drained and gravelly or non-gravelly and are characterized by accumulation of clay. The surface texture ranges from loamy sand to sandy clay loam and sub-soil texture from sandy clay loam to sandy clay and clay. The red soil covers nearly 37.3% of the total geographical area of the State and is distributed in all the districts except Bidar.

Laterite Soils cover an area of about 6.16% of the total geographical area of the State. Lateritic soils of Bangalore, Kolar, Bidar and Gulbarga have been formed under paleoclimate and form a plateau that is presently under disintegration. The laterite soils of malnad i.e., Belgaum, Hassan, Chikmagalur, Uttara Kannada, Udupi and Kodagu districts have developed under the sub-humid and humid climate. They occur as plateaus at the foothills of Western Ghats and have developed on gneisses, schists and phyllites.

Black Soils occupy around 27.77% of total geographical area of the State. They occur on plateau summits, slopes and valleys developed from basalt in northern Karnataka. They are also known as swell-shrink soils. This is due to alternative wetting and drying processes. The infiltration rate and hydraulic conductivity of black soils are very low. Based on soil depth, these soils are grouped as shallow, medium and deep black soils.

Alluvial Soils are present in the Western Ghats and Deccan plateau and are transported from higher elevated areas by the flowing water and deposited in valleys and lowlands. These soils occupy nearly 15.74% of the total geographical area of the State. Majority of the area is under irrigation in the plateau region and is under rain-fed cultivation in Malnad and the Western Ghats. The alluvial soil is generally very deep, moderately well drained to imperfectly drained and well

drained. They have textures of loam to clay loam, clay and cracking clay, stratified with light and heavy textures.

Brown Forest Soils occur mainly in the Western Ghats under forests, in humid and sub-humid climate. They cover 6% of the total geographical area and have developed on granites, gneisses and schists. They are deep to moderately deep, well drained to excessively drained and have sandy clay to clay and sandy loam surface soils and clay to sandy clay sub-soil with high content of clay.

Coastal Soils occur in the West Coast of Karnataka between the Western Ghats and the Arabian Sea. They occupy approximately 3.9% of the total geographical area of the State. They are of two types viz., a) Coastal laterite soils and b) Coastal alluvial soils.

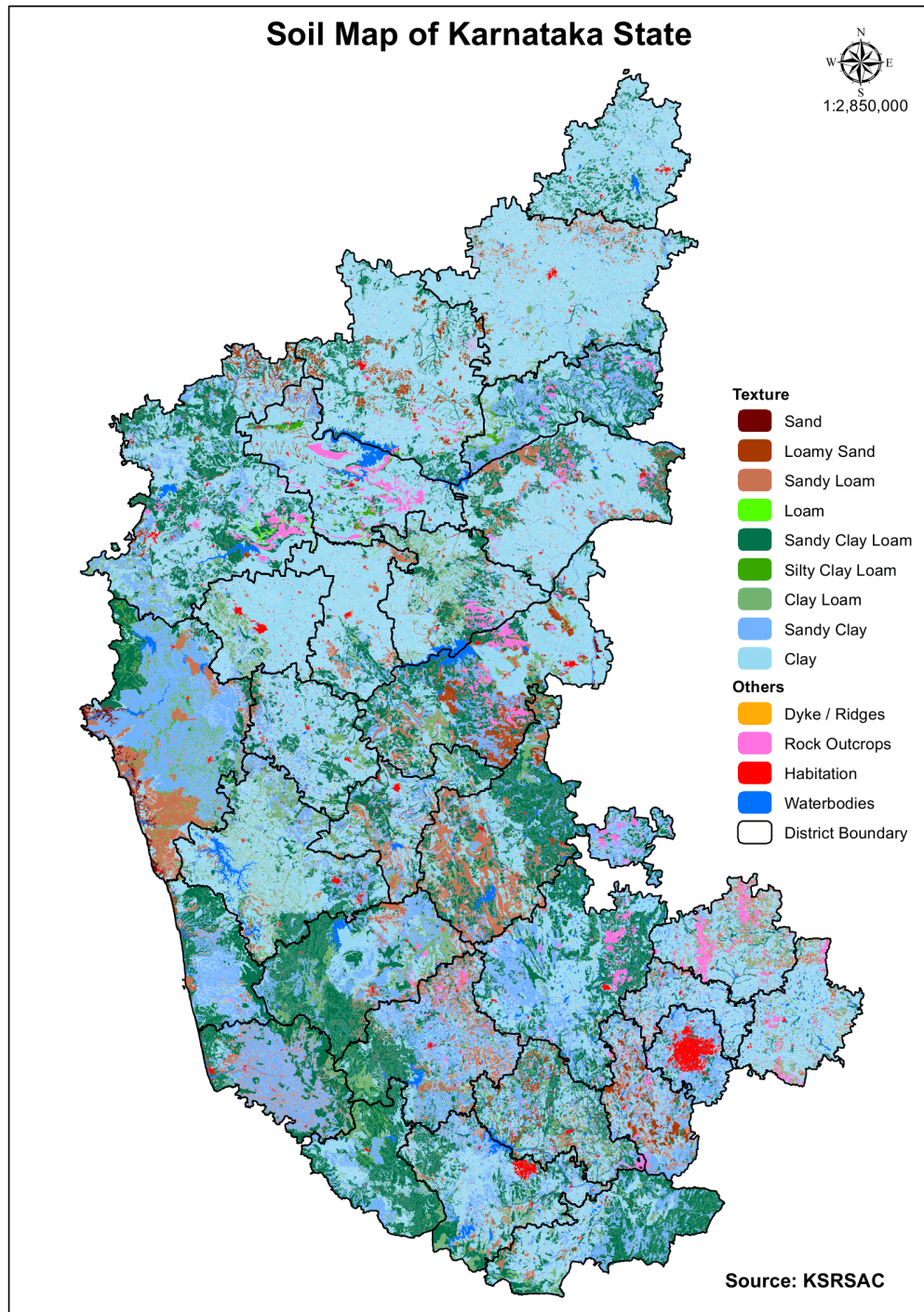


Figure 8: Soil texture map of the project activity

Hydrology

There are six river basins in the State of Karnataka – Cauvery, Krishna, Godavari, East flowing – Cape Comorin to Sharavathy and Sharavathy to Tapthi and between Cauvery and Krishna (Pennar, Palar). The major area of the State lies in the Krishna basin. In the Western Ghats and malnad regions, the drainage network is dense. Rivers Krishna and Godavari flow from Maharashtra State, whereas rivers Cauvery, Palar and Pennar rise in the State. The West flowing rivers rise in the Western Ghats and finally, find their way into the Arabian Sea.

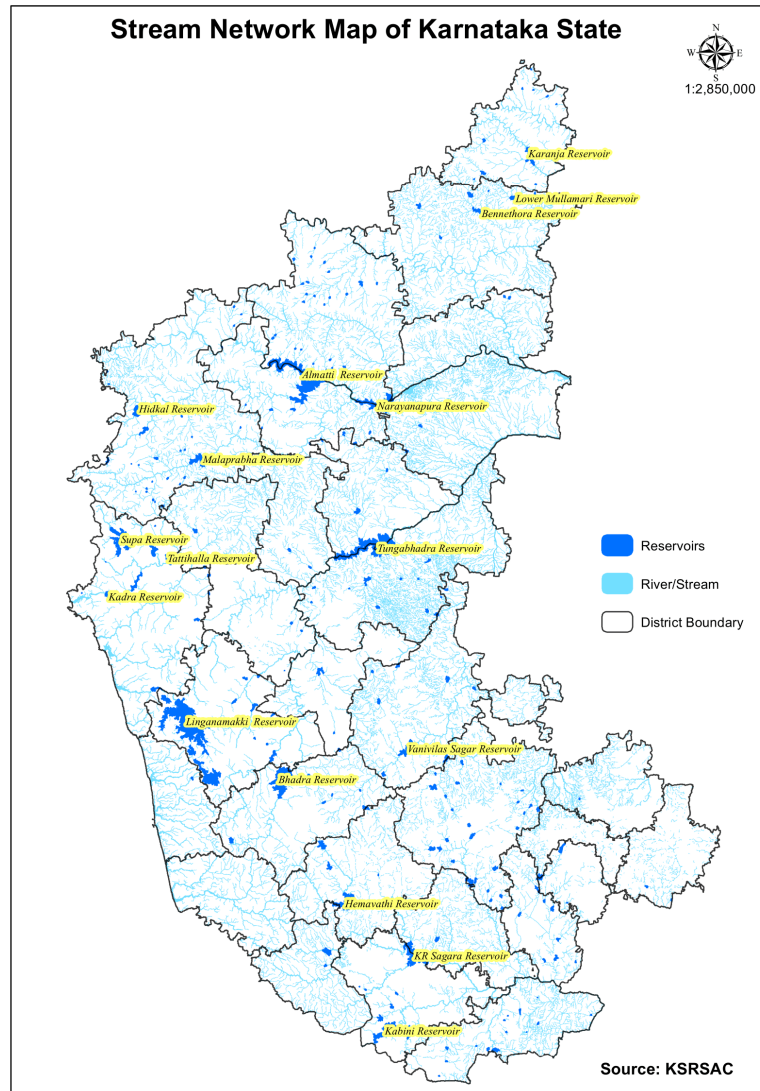


Figure 9: Hydrology map of the project activity

Climate

The climate of the State is determined mainly by the geographical location with respect to the sea, monsoon winds and physiography. Karnataka State has a very moist monsoon climate on

the West Coast, semi-arid climate in the Western Ghats and Malnad areas, and arid (very warm) climate in the central and northern districts. The year is divided into four seasons viz., summer season from March to May; South-West monsoon from June to September; North-East monsoon season from October to December; and Winter season from January to February. In the North-East monsoon season, the wind regime changes from South-West or West to North-East. This is the season during which occasional depressions and cyclones from the Bay of Bengal strike the Chennai Coast and move towards West or North-West, causing widespread rain over the southern parts of the State.

Vegetation

The main vegetation categories in Karnataka are mentioned below:

i) Evergreen and Semi-evergreen

An evergreen forest is a forest consisting entirely or mainly of evergreen trees that retain green foliage all year round and Semi-evergreen forests are generally considered as a transitional stage between evergreen and moist deciduous forests. These forests are characterized by evergreen trees mixed with deciduous having typical features like less dense canopy, green gariousness, frequent buttressed trunks, thicker and rougher barks, and heavy climbers. Ex: *Dipterocarpus indicus*, *Hopea parivflora*, *Myristica fatua*, *Gymnacranthera canarica*, *Vateria indica* etc.

ii) Moist Deciduous

Temperate deciduous forests are located in areas that have moderate rainfall and temperature with cold winters. These are the typical monsoon forests in areas where the annual rainfall ranges between 100 cm and 150 cm with a mean annual temperature of 24 °C to 27 °C, and humidity percentage of 60 to 80. They mostly occur along the eastern slopes of the Western Ghats, north-eastern part of the Peninsula. teak (*Tectona gradis*) are commercially the most significant species, occupying the relatively wetter north-eastern parts of the Peninsula. Ex: *Terminalia*, *Largerstroemia*, *preterocarpus*, *Xylia*, *Tectona* and *Anogeissus* etc.

iii) Dry Deciduous Forest

The tropical deciduous forests shed leaves during December (in Northern Hemisphere) as water becomes scarce. This type is a degraded version of the moist deciduous. It occupies a vast area of the country between moist deciduous (in the east) and tropical thorn (in the west) forests. Ex: *Acacias*, *Hardwickia*, *Neem*, *Pongamia*, *Somida*, *Santalum album*, *Ficus* etc.

iv) Scrub and Thorny Forest

These forests are confined to areas where the rainfall is very low. Here due to the paucity of rainfall the trees are stunted with large patches of coarse grass. The typical vegetation consists of widely spaced acacias, euphorbias including the typical spiny and thorny varieties and clumps of wild palms (*Phoenix Sylvester's*) here and there. Ex: *Acacia* species, *Balanites roxburghii*, *Cordia myxa*, *Capparis spp.*, *Prosopis spp.*, *Azadirachta indica*, *Cassia fistula*, *Diospyros chloroxylon*, *Carissa carandas*, and *Phoenix sylvestris* etc.

v) Un-wooded

These forests are mainly grasslands and wasteland.

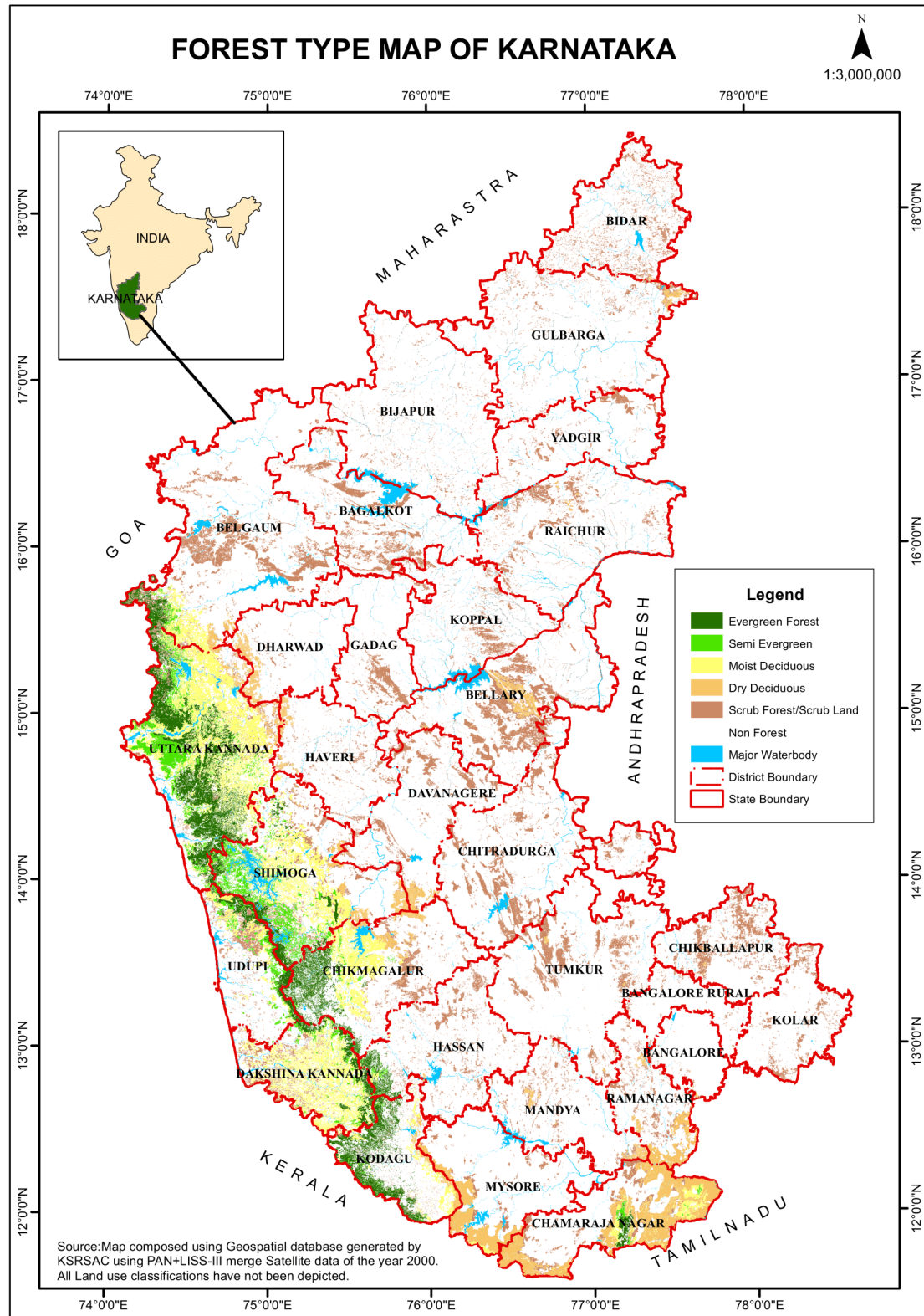


Figure 10: Forest type map of the project activity

Ecosystem Type

The climate of Karnataka is Semi-tropical with an average annual rainfall of 1355 mm. The forest type in Karnataka is evergreen and semi-evergreen, moist deciduous, dry deciduous, scrub and thorny forest and un-wooded forest. The common type of soil groups found are red soil, black soil, lateritic soil and black soils.

- Current and historical land-use: The condition prior to the project initiation in the project area is crop land or agriculture land.
- Has the land been cleared of native ecosystems within 10 years of the project start date?

 Yes No

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

The SALM project activity follows all the applicable legal and regulatory requirements. Currently no laws and regulations prevent or enforce the project activity or baseline land use scenarios. However, the project meets the objectives of the National Agroforestry policy, 2014, National Mission on Sustainable Agriculture (2010) and the organic farming Policies of the state government (Govt. of Karnataka).

National Policies

National Mission for Sustainable Agriculture (NMSA)

The Ministry of Agriculture and Farmers Welfare, Government of India launched NMSA to promote sustainable agriculture. The mission encompasses all three dimensions of sustainability. The centrally sponsored schemes under the mission are: i) Rainfed area development ii) Sub-mission on Agroforestry (SMAF) iii) Soil health management and iv) Paramparagat Krishi Vikas Yojana (PKVY). PKVY scheme intends to encourage commercial organic farming in India by creating an organic certification system.

Regional Policies

Karnataka Organic Farming Policy

The state government launched the Karnataka Organic Farming Policy 2017, in order to enable the next level of development in Organic farming. The policy strategies included organic farming in mainstream agriculture, focus on region and season specific crops to increase farm output and income.

In order to keep the momentum of agricultural development, the Government of Karnataka formulated a State Policy on encouraging Organic Farming with focused approach towards conservation of biodiversity, mixed farming, soil and water conservation including rainwater harvesting, on farm production of organic manures and land regeneration. This project provides

additional benefits to the farmers by quantifying the avoidance and sequestration of carbon emissions and assisting them to implement the SALM practices to meet the policy requirements.

1.15 Participation under Other GHG Programs

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

The project has not been registered or seeking registration under any GHG programs. The declaration to this effect has been submitted to the VVB.

1.15.2 Projects Rejected by Other GHG Programs

The project has not been rejected under any other GHG programs. The declaration to this effect has been submitted to the VVB.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

The net GHG emission reduction or removal generated by this project is voluntary and, will not be used for compliance with an emission trading program, or to meet binding limits on GHG emissions. The project activity is an agricultural project, and it is not eligible under the Kyoto Protocol because there is no emission trading limits for agriculture projects in non-annex I countries.

Does the project reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that include GHG allowance trading?

Yes No

1.16.2 Other Forms of Environmental Credit

The project is not planning to participate under any other forms of environmental credits.

Has the project sought or received another form of GHG-related credit, including renewable energy certificates?

Yes No

1.17 Sustainable Development Contributions

1.17.1 Sustainable Development Contributions Activity Description

The Sustainable Development Goals (SDGs) also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity. There are 17 SDGs in total with each goal

having their own set of targets. The National Institution for Transforming India (NITI Aayog), the premier policy think tank of the Government of India, has created the SDG India Index which covers 16 out of 17 SDGs (excluding SDG 17). The SDG India Index emphasizes on holistic approach to assess environmental, social and economic status of the country. This project contributes to achieving the following SDG goals:

- Goal 1 No Poverty
- Goal 13 Climate action
- Goal 15 Life on land

Sustainable Development Contributions Activity Monitoring

SDG 1: End poverty in all its forms everywhere

The project promotes Organic agriculture, which is a key antipoverty strategy in rural areas, providing rural employment, lowering input costs for small farmers, and raising incomes by offering premium prices for produce. It also enhances farm biodiversity and resiliency considering weather patterns, which have become increasingly extreme and erratic.

SDG 13: Take urgent action to combat climate change and its impacts

Under organic agriculture, the carbon footprint of the sector is reduced owing to the following: i) synthetic fertilizers, which are fossil-fuel based and whose production is energy-intensive, are not used; ii) organic practices build soil organic matter, which help sequester carbon from the atmosphere and enhance the carbon storing capacity of soil iii) organic operations perform better on a per hectare scale than conventional agriculture with high level of efficiency of energy use. Carbon sequestration from the atmosphere through soil rehabilitation also positively impacts SDG 13 in mitigating climate change.

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Organic agriculture can reduce and even reverse the degradation effects of conventional agriculture to the soil. Mulching of crop residue restores the life in soils, which is an important carbon sink. Agroforestry systems reverse the effects of land degradation.

Table 5: Sustainable Development Contributions

Row number	SDG Target	SDG Indicator	Net Impact on SDG Indicator	Current Project Contributions	Contributions Over Project Lifetime
1)	1.0	No poverty	Implemented activities aim to decrease the level of poverty	Organic farming has long-term positive effects on crop productivity and ultimately income security. Farmers can enhance the capacity of soil by using sustainable agronomic practices such as mulching, green manuring, proper crop residue management etc. Compared to conventional farming. The use of such SALM methods qualifies the farm produce as eligible organic produce which can be sold at higher rates which is about 10-15% more than the local rates. Further the net returns / hectare on average were around 20% more. The benefit to cost ratio increased to about 40% for major crops like ragi and maize.	The project will increase the overall soil fertility by application of organic fertilizer. and provide added benefits on the higher rates at which organic produce is sold and the higher net returns /hectare. The benefit to cost ratio is expected to increase to about 40% for organic farming which will ensure better profitability and increase the economic well-being.

2)	13.0	Total greenhouse gas emissions per year tCO ₂ e.	Implemented activities aim to decrease the total greenhouse gas emissions	Strengthening resilience and adaptive capacity of agriculture to the impacts of climate change and lowering greenhouse gas emissions without affecting crop production. During this monitoring period, the project has generated net environmental benefits calculated as 996,584 CO ₂ e.	<p>The project has planned to generate an estimated GHG emission reductions or removals of 171,399 tCO₂e / year.</p> <p>This projects climate benefits include emissions reduction or removals of approximately 5,141,971 tCO₂e over the lifetime of the project.</p>
3)	15.3	Combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	Implemented activities to increase soil fertility	Due to the reduced use of inorganic fertilizers and other SALM practices such as Agroforestry, the degradation of land will be less. During this verification period, a quantifiable increase of organic carbon was observed in the soil. During this period, the total number of trees planted which could sequester the carbon was on average 60 trees / hectare.	During the lifetime, due to the implementation of SALM activities, the fertility of the soil and consequently the improvement of the soil flora and local biodiversity is expected to improve. The trees planted per farm are expected to increase throughout the lifetime and the overall sequestration of carbon is expected to increase. Every year there are a minimum of 8-10 trees to be planted on each farm to achieve an objective of 30% tree cover in 7-8 years.

1.18 Additional Information Relevant to the Project

Leakage Management

Leakage is not applicable for this project as monitored during the verification period. The land is being used for cultivation of crops. Hence there is no shift in activities viz., grazing, fuel wood collection for cooking etc.

Commercially Sensitive Information

There is no commercially sensitive information in the documents submitted to the VVB.

Further Information

Not applicable.

2 SAFEGUARDS

2.1 No Net Harm

There are no significant negative impacts on the farmer community and hence there is no need for mitigation. The ongoing stakeholder consultation process has identified no major grievances or negative inputs from the farmer associations. Based on the results of the baseline survey, the feedback from the farmers representing the different socio-economic groups indicated the various types of risks they face due to adoption of the SALM practices. The socio-economic analysis accounted for the land holding capacity, education, main occupation, family size, type of house, caste etc. (as indicated in the **Appendix 2**) The mitigation actions implemented by the project indicated a satisfactory level of outcome as indicated in the feedback provided during the ongoing stakeholder consultation.

Around 94% of the farmers identified positive aspects of the project and as such there are no major negative environmental impacts identified. The remaining farmers expressed their apprehensions as they were not aware of the overall benefits of such projects and the process for their implementation. The project team assured them that awareness program and training would be provided so that they are aware of the benefits of the project and are aware of the SALM practices. As there were no other negative comments, in this context, it was assessed that there is no need for any further mitigation measures to be adopted. However, the project is designed to accommodate modifications or changes to the project design, to address any such related grievances in the future.

The tree species considered for the project activity are native species or naturalized species, which are recommended by the Karnataka Govt¹⁵. The farmers are also apprehensive of any new species which are potentially invasive. Hence no invasive species are considered for the Agroforestry practices. Though analysis of the tree planting monitoring data submitted to VVB indicated that the overall planted population of Eucalyptus is less than 5% and it is commonly included in many agroforestry schemes in

¹⁵ <http://e-krishiuasb.karnataka.gov.in/ItemDetails.aspx?depID=9&subDepID=+6&cropID=0>

India, it is being removed now for conservativeness and the revised sheets have been submitted to the VVB.

The use of chemical pesticides, biological control agents and agro chemicals remained similar based on usage data in the baseline and project monitoring. This is due to the reason that they are specific to the crop type and not the SALM practices adopted. The goal of the project is to reduce the agrochemicals usage and adopt organic practices to minimize its risk on the environment and on the local community. However, during project scenario, the increase in the usage of organic inputs demonstrates the increased SOC in soil, as indicators on the minimal risks and improved biodiversity in the project area and improved soil health.

2.2 Local Stakeholder Consultation

The district level exhaustive meetings were held and the meetings with stakeholders with all the members, further reviews are conducted in all the district project areas. The farmer associations were given due notice before conduct of the meeting. The associations invited the farmers to these meetings where the details of the SALM activities and implementation and design of the project were explained by VGS representatives. Further the benefits of the projects were explained, and feedback was received by survey forms and queries received were replied by the VGS staff.

Different kinds of stakeholders were identified as relevant and invited:

- the farmers
- Farmer association representatives
- the representatives
- the farmer societies
- Non-Governmental Organization, etc.

First, VGS introduced the idea of ALM in 2017 in different districts of Karnataka. Then, each Entity socialized the project in each community through participative meetings. Farmers willing to voluntarily participate in the project were registered in these preliminary meetings. Each interested farmer was then individually visited, in order to assess eligibility and his land, to conduct biophysical evaluation of the area, to determine the planting models and the choice of species.

As the project was designed and proposed in a participative way, and because it is managed by each entity in a very cooperative way, each farmer can at any time give advice or recommendations, as a full owner of the project via his Project Entity. Farmer associations conduct stakeholder meetings periodically in which farmers provide feedback on the status of the project implementation and discuss the benefits from the project and also clear their queries if any. Ongoing local stakeholder consultations are held periodically with the farmer associations in which the relevant stakeholders (farmers who are members) participate. The evidence of the minutes of the meeting conducted during this verification period is submitted to VVB.

The project proponent explained the process to stakeholders and community members about VCS Program validation and verification and the validation/verification body's site visit. The project proponent requested all the stakeholder cooperation to VVB during the validation process.

Meetings were conducted prior to the project starting between May to July 2017 at the various districts as indicated in Table below. The supporting documents are submitted to the VVB.

Table 6: Location of Stakeholder meetings conducted

S. No.	District Name	S. No.	District Name
1	Bagalakote	15	Hassan
2	Bengaluru	16	Haveri
3	Bengaluru Rural	17	Kodagu
4	Belagavi	18	Kolar
5	Bellary	19	Koppal
6	Bidar	20	Mandya
7	Chamarajanagar	21	Mysore
8	Chikkamagalur	22	Raichur
9	Chitradurga	23	Ramanagara
10	Dakshina Kannada	24	Shivamogga
11	Davanagere	25	Tumkur
12	Dharwad	26	Udupi
13	Gadag	27	Uttara Kannada
14	Kalaburagi	28	Vijayapura

Summary of the comments received:

The project was generally well accepted as indicated in the comments summarized below:

- Farmers are proud to be part of a climate change mitigation program.
- The producers also declared they were very interested in the possibility of developing projects for carbon sequestration. The project will help them access this new market.

Some doubts or requests were taken into account:

- a. Will a real efficient monitoring process be implemented? (they've heard of, or known other projects led by other entities that did not include follow-up in the long run)
- b. Will the farmers receive training in agroforestry and forestry practices?
- c. The farmers requested additional species to be planted

Report on how due account was taken of any comments received:

In the project development, all these questions were taken into account:

- a. A monitoring plan has been developed, and the cooperative is highly conscious that monitoring in the long run is crucial for the development and permanence of the project.
- b. The farmers will receive training as detailed in the farmers training plan.

c. The choice was made in agreement with farmers' choice, seedlings availability, and species-site matching.



Figure 11: Stakeholder consultation meeting



Figure 12: Distribution of Organic Fertilizers at Farmers Associations



Figure 13: Training on SALM practices and Soil health conservation



Figure 14: Ongoing stakeholder consultations and training camp

2.3 Environmental Impact

As the project involves implementation of SALM practices by the farmer association, the VGS Project team has not identified any major risk or impact to any local stakeholders, to their property rights and natural resources. As per the Govt. India, EIA Notification, 2006 the requirement to conduct an EIA study is not mandatory for this project. Hence as EIA is not applicable, it was not performed. However, some of the risks and barriers faced by the organic farmers associations as discussed during the periodic meetings are summarised as below:

Production Risks: Many of the organic farmers or with natural land management practices, noted that weather and climatic risks are similar for organic and conventional farmers.

Others pointed out that any farmer without irrigation faces the risk of drought, but that organic farmers' investment in soil quality allows their soils to hold water and withstand drought better than those of their conventional counterparts.

While diseases, insects and, especially, weeds can cause problems for organic farmers, in meetings most said that though farmers use best practices to prevent pest problems from developing and to reduce risks from pests, still few problems are observed such as reduced in yield for first three year in the land conversion period. But by crop diversification, such risks can be minimised.

Input Risks: Organic farmers on many occasion face shortages of certified organic seeds, biological pesticides, specialized farm equipment designed for organic cultural practices and other inputs.

The access to capital is a risk for organic farmers because banks are unfamiliar with organic production systems and have difficulty evaluating creditworthiness. As a result, the flow of credit to organic producers is limited and can be difficult to obtain.

Organic Marketplace Risks: The Price premiums are less stable and are dropping in some cases.

Potential of invasive species: The tree species considered for the project activity are native species or naturalized species, which are recommended by the Karnataka Govt. The farmers are also apprehensive of any new species which is potentially invasive. Hence no invasive species are considered for the Agroforestry practices. Though analysis of the tree planting monitoring data submitted to VVB indicated that the overall planted population of Eucalyptus is less than 5% and it is commonly included in many agroforestry schemes in India, it is being removed now for conservativeness and the revised sheets have been submitted to the VVB.

2.4 Public Comments

During the public comments period from 17/06/2022 to 17/07/2022, no comments were received.

2.5 AFOLU-Specific Safeguards

The VGS Project team has not identified any major risk or impact to any local stakeholders, to their property rights and natural resources from the implementation of this project activity. The feedback from the local stakeholder meetings held with the farmer associations indicated a very low risk based on the population surveyed. For, some of the existing risks prior to project implementation as identified in section 2.3 mitigation measures were proposed. Most of the communities welcomed the initiatives of the project. However, the identification of risks will be on-going process throughout the project implementation.

In the context of this project, the location of the project is defined by the agricultural land owned by the farmer. The details of the same (KML file with the farm boundary) has been provided to the VVB. The analysis of the social, economic and cultural diversity within local stakeholder groups and the differences and interactions between the stakeholder groups have been analysed and provided to the VVB. It is observed that the farmers association decide on the eligibility of the farmer based on the previous land use agricultural practices. Hence the association itself is representative of comprising of farmers from different socio-economic backgrounds based on the education, size of landholding, caste and family size.

The socio- economic survey conducted for the farmers participation in the project activity has been summarized in Section 2.1 of the PD. Around 94% of the farmers identified positive aspects of the project. The remaining farmers expressed their apprehensions as they were not aware of the overall benefits of such projects and the process for their implementation. The project team assured them that awareness program and training would be provided so that they are aware of the benefits of the project and are aware of the SALM practices. As there were no other negative comments, in this context, it was assessed that there is no need for any further mitigation measures to be adopted. However, the project is designed to accommodate modifications or changes to the project design, to address any such related grievances in the future.

The farmer associations coordinate the interaction with the farmers who are the stakeholders. As the associations represent the farmers and the field workers employed by VGS are from the same state (Karnataka) /geographical region and share common language/culture it is ensured that communication and consultation to stakeholders (farmers) are performed in a culturally appropriate manner, including language and gender sensitivity. The same was verified from feedback from the farmer which indicated an overall satisfactory outcome.

The statement that neither the project proponent nor any other entity involved in project design or implementation are involved in any form of discrimination or sexual harassment has been provided by the PP and submitted to the VVB.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

Approved VCS methodology VM0017: Adoption of Sustainable Agricultural Land Management (version 1.0)

3.2 Applicability of Methodology

This methodology is applicable to projects that introduce sustainable agriculture land management practices (SALM) into an agricultural landscape subject to the following conditions:

Applicability conditions	Explanation
a) Land is either cropland or grassland at the start of the project	The lands owned by the farmers are designated for agricultural purpose only. Section 1.3 of the VCS PD describes the historical land use of the project activity instance which confirms the land as cropland. From the historical survey it was verified that the land use at the project start date was cropland.
b) The project does not occur on wetlands	As already established the project activity falls in cropland category and therefore does not occur on wetlands. The Satellite imagery (2006-07) of the project area showed no signs of such water bodies within the project boundary. All the land parcels have extensive agricultural activities based on the seasonal rainfall & soil suitability.
c) The land is degraded and will continue to be degraded or continue to degrade	As the project activity is implemented on the farmlands it is a crop land. The historical trends have shown the decrease in the fertility of the soil due to the unsustainable agricultural practices and in the absence of the project will lead to the degradation of the farmland.
d) The area of land under cultivation in the region is constant or increasing in absence of the project;	The area under crop land has shown a constant trend of increase in the project area. According to National Remote Sensing Centre, ISRO, Hyderabad land use land cover data for the years 2005-06 (Figure 1) and 2015-16 (Figure 2), the area under cultivation follows an increasing trend in the project area.
e) Forest land, as defined by the national CDM forest definition, in the region is constant or decreasing over time;	A geospatial study in 2016 (TV Ramachandra et.al, 2016) showed the regions in Karnataka having the highest forest cover in the state such as Central Western Ghats has been experiencing changes in its forest cover and consequent alterations in functional abilities of its ecosystem. Temporal land

	<p>use analyses show the trend of deforestation, evident from the reduction of evergreen -semi evergreen forest cover from 57.31 % (1979) to 32.08 % (2013) Forest fragmentation at the landscape level shows a decline of interior forests 64.42 % (1979) to 25.62 % (2013) and transition of non-forest categories such as crop land, plantations and built-up areas, amounting now to 47.29 %. Hence there is a decreasing trend of forest cover.</p>
<p>f) There must be studies (for example, scientific journals, university thesis, local research studies or work carried out by project proponents) that demonstrate that the use of the RothC model is appropriate for: (a) the IPCC climatic regions of 2006 IPCC AFOLU Guidelines, or (b) the agro-ecological zone (AEZ) in which the project is situated.</p>	<p>According to IPCC climate regions, the project activity instance is in tropical dry, tropical moist and tropical wet zone. The following studies have been selected to demonstrate that the application of the RothC model is appropriate and that the model is validated for similar IPCC climate regions.</p> <p>Simulating Soil Organic Carbon Stock Under Different Climate Change Scenarios: A RothC Model Application to Typical Land-Use Systems of Goa, India" (Paramesh et al., 2022):¹⁶ This research assessed the effects of climate change on SOC stocks across various land-use systems in Goa, India, which spans the Tropical Wet and Tropical Moist zones¹⁷. Hence the applicability condition is met. The study concluded that ROTH C model can effectively predict soil carbon dynamics under Indian environmental and climatic conditions by providing accurate initialization and parametrization of the model. Simulating soil organic carbon stock under different climate change scenarios: A RothC model application to typical land-use systems of Goa, India Paramesh, Venkatesh, et al. "Simulating soil organic carbon stock under different climate change scenarios: A RothC model application to typical land-use systems of Goa, India." <i>Catena</i> 213 (2022): 106129.</p> <p>Bhattacharya, et al. (2011) - This study analysed the effect of land use management including manure application on total organic content of soil in Indore district of Madhya Pradesh state, India. Application of RothC model in this study revealed that</p>

¹⁶ <https://www.sciencedirect.com/science/article/abs/pii/S0341816222001151>

¹⁷ Refer to the IPCC Global Map at the following link: [IPCC Climate Zones](#)

	supplement of organic materials coupled with fertilizers can increase the SOC sequestration. Hence the applicability condition is met. Ref: Bhattacharyya, T., et al. "Evaluation of RothC model using four Long Term Fertilizer Experiments in black soils, India." Agriculture, ecosystems & environment 144.1 (2011): 222-234.
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Further, the following tools have been applied in line with the methodology:

- Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities, version 1.0. This tool is applied as the project falls under the AFOLU category as the proposed project activity on the land within the proposed project boundary performed with or without being registered as the VCS AFOLU project shall not lead to violation of any applicable law even if the law is not enforced; b) The use of this tool to determine additionality requires the baseline methodology to provide for a stepwise approach justifying the determination of the most plausible baseline.
- AFOLU Non-Permanence Risk Tool v4.0, published on 19-September-2019. – This tool is applied as it is mandatory for conducting the non-permanence risk analysis to determine the non-permanence risk rating (“risk rating”), which shall be used to determine the number of buffer credits that an AFOLU project shall deposit into the AFOLU pooled buffer account (the procedure for deposit of buffer credits is set out in the VCS Program document Registration and Issuance Process). The risk rating assessed using the risk report has been submitted to the VVB.

3.3 Project Boundary

Source	Gas	Included?	Justification/Explanation
Baseline	Inorganic fertilizer	CO ₂	No Negligible emission from application of organic fertilizer, hence not considered
		CH ₄	No Negligible emission from application of organic fertilizer, hence not considered
		N ₂ O	Yes Considered as main emission from use of synthetic fertilizer
Biomass burning*		CO ₂	No Not Considered as per methodology
		CH ₄	Yes Considered as crop burning is prevalent
		N ₂ O	Yes Considered as crop burning is prevalent

Source		Gas	Included?	Justification/Explanation
Project	Organic fertilizer	CO ₂	Yes	Considered as organic carbon is sequestered by use of organic fertilizers and avoidance of crop burning
		CH ₄	Yes	Emission from application of organic fertilizer considered
		N ₂ O	Yes	Emissions from application of organic fertilizer, considered
	Aboveground biomass	CO ₂	Yes	Considered as trees sequester CO ₂ as part of the agroforestry
		CH ₄	No	Negligible emissions, hence, not considered
		N ₂ O	No	Negligible emissions, hence, not considered
Belowground biomass	CO ₂	Yes	Considered as trees sequester CO ₂ as part of the agroforestry	
	CH ₄	No	Negligible emissions, hence, not considered	
	N ₂ O	No	Negligible emissions, hence, not considered	

**Biomass burning is observed in the baseline. As the project promotes retention of crop residue such as mulching, it indirectly reduces burning. However, for conservativeness, Emission reductions due to avoidance of biomass burning are not claimed.*

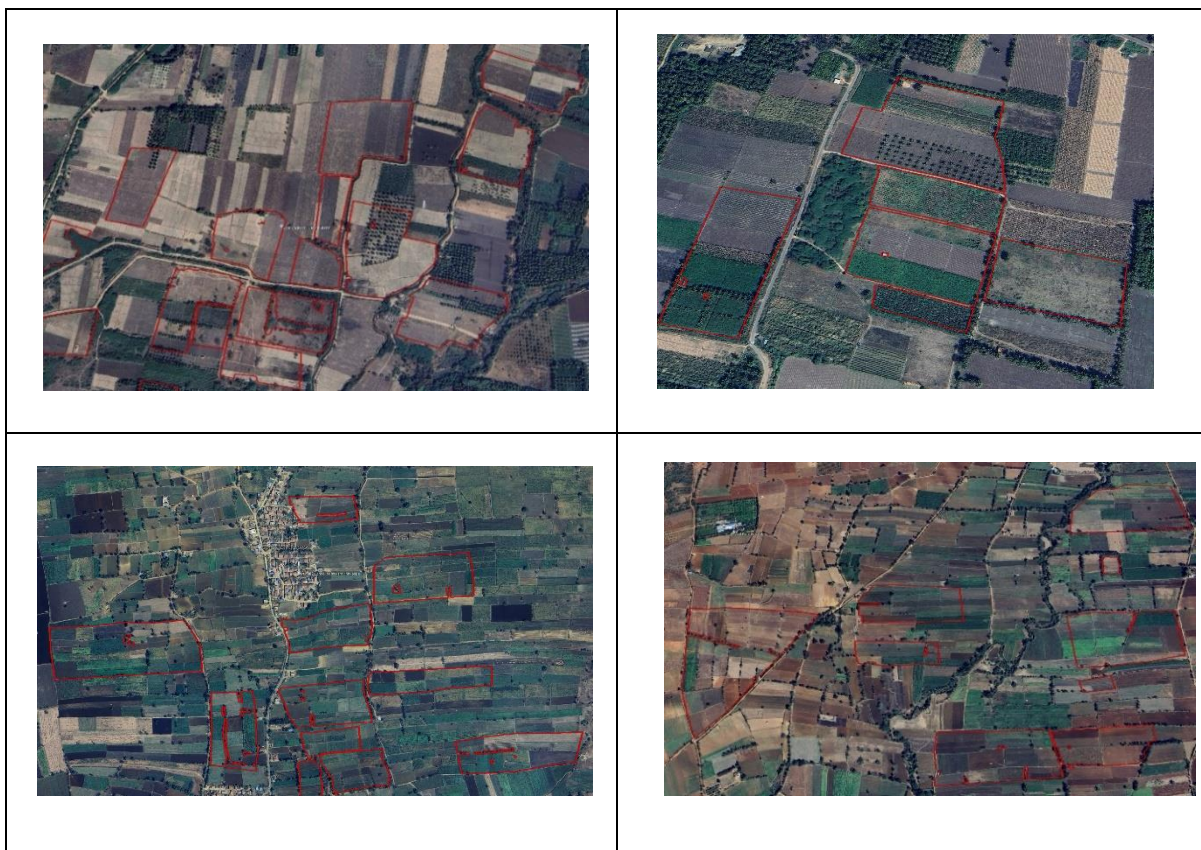


Figure 15: Typical project areas, i.e. farm areas where SALM is implemented -eligible for accounting

According to the template requirements, for AFOLU projects a diagram or map of the project boundary, showing clearly the physical locations of the various installations or management activities taking place as part of the project activity based on the description provided in Section 1.11 (Description of the Project Activity) above is to be provided. As the project boundary is the individual farm, the KML of the farm boundary delineating the eligible project area is provided to the VVB. VGS has submitted the clear demarcations of the eligible and ineligible cropland area excluding water bodies, buildings, roads etc and SOP is provided to the VVB. The file is also submitted to VERRA during the resubmission.

3.4 Baseline Scenario

According to the VM0017 methodology, the project proponent shall use the most recent version of the combined tool to identify the baseline scenario and demonstrate the additionality in A/R CDM project activities. The baseline scenario is recognized as existing or historical land management practices. Thus, the initial project activity instance is using the tool - “Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities”, version 1.0.

The PP has submitted an agreement with the farmers which indicates that the revenue from the sale of

carbon credit was an important factor that was considered in the decision to proceed with the project activity. Further this was also discussed during the FPIC consultations prior to the project implementation as observed in the minutes of the meeting submitted to the VVB.

Conditions existing prior to the project:

Use of Chemical Fertilizers:

The Kharif crops in Karnataka comprise millets, paddy (rice), maize, moong (pulses), groundnut, red chilies, cotton, soybean, sugarcane, rice, and turmeric. Great millet, wheat, Maize, Cotton, Bajra, Chilies, Onion, and Groundnut are the major crops grown in Rabi season.

According to the State of biofertilizers and organic fertilizers in India report (2022) ¹⁸Per hectare chemical fertilizer consumption in India has been increasing—it was 92 kg/ ha in 2000–01 and rose to 161 kg/ha in 2020–21, marking a growth of 75 per cent. Heavy government subsidy for chemical fertilizers have fueled their high usage compared to non-chemical fertilizers. The growth in average per hectare consumption of fertilizers has expectedly reflected the subsidy provided over the last two decades.

According to a statement by the Indian Council of Agricultural Research (ICAR) ¹⁹in 2014, the organic content in the soil in India had decreased to 0.3 to 0.4 % which is well below the acceptable limit and is a cause for concern. According to ICAR, SOC should be between 1 to 1.5 per cent, but has decreased rapidly because of increasing atmospheric temperature, over exploitation, extensive mining of soil fertility, soil degradation, inappropriate soil tillage, poor crop management, indiscriminate use of fertilizer, and accelerated soil erosion.

According to the fertilizer usage statistics for 2012-2013, Karnataka uses 15.31 lakh tons of inorganic fertilizer / year which comprise of the commonly used NPK fertilizers.

Practice of Agroforestry system:

Agroforestry systems in Karnataka face various issues. Traditional systems still prevail, but the type and composition of tree species, their distribution, and extent vary based on biophysical and socioeconomic factors. Agroforestry is not commonly practised as the forest cover in the State. A geospatial study in 2016 (TV Ramachandra et.al, 2016) showed the regions in Karnataka having the highest forest cover in the state such as Central Western Ghats has been experiencing changes in its forest cover and consequent alterations in functional abilities of its ecosystem. Temporal land use analyses show the trend of deforestation, evident from the reduction of evergreen -semi evergreen forest cover from 57.31 % (1979) to 32.08 % (2013) Forest fragmentation at the landscape level shows a decline of interior forests

¹⁸ State of biofertilizers and organic fertilizers in India report (2022)

¹⁹ ICAR statement

64.42 % (1979) to 25.62 % (2013) and transition of non-forest categories such as crop land, plantations and built-up areas, amounting now to 47.29 %. Hence there is a decreasing trend of forest cover.

Step wise assessment based on the tool is applied as below:

Step 0: Preliminary screening based on the starting date of the A/R project activity. According to this step the following are required to be established:

- Provide evidence that the starting date of the A/R CDM project activity was after 31 December 1999.
- Provide evidence that the incentive from the planned sale of CERs was seriously considered in the decision to proceed with the project activity. This evidence shall be based on (preferably official, legal and/or other corporate) documentation that was available to third parties at, or prior to, the start of the project activity.

The demonstration and assessment of the additionality of the project is made in accordance with the applied methodology VM0017 Adoption of Sustainable Agricultural Land Management, v1.0, following the steps of the “Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities” (Version 01).

Project start date is 01.10.2017 based on the first instance added. Based on VCS requirements, the start date is based on the initiation of the implementation of SALM practices in the farm level. The earliest date of the farmer associations adopting the practice of SALM and signing the agreement with the project developer is hence considered as the appropriate start date. The evidence has been provided to the VVB. Hence the date qualifies as conforming to the definition of start date as per VCS requirements.

The revenue and incentive from the planned carbon credits and its sales in the market was seriously considered in the decision to proceed with the project activity. Further to the discussions with stakeholders (farmers) prior to the project, the PP has clarified that proceeds from sale of carbon credits is integral to the project activity and that such benefits are to be shared with the farmers. The agreement signed with the farmers indicated that the benefit sharing mechanism was in place, and the farmers were aware that funding from sale of carbon credits was necessary and have then accepted to join in the project. This clearly demonstrating that GHG revenues (i.e., income from carbon credit marketing) were accounted strongly before the implementation of the initial project plan. The documents such as minutes of stakeholder meeting and agreement with farmers are provided to VVB.

Step 1: Identification of alternative land use scenarios to the proposed A/R CDM project activity

Sub-step1a. Identification of alternative land use scenarios to the proposed project activity

The following alternatives are considered:

Alternative 1. The continuation of the land-use and management existing prior to the implementation of the project activity with unsustainable practices may lead to the loss in soil nutrients and degradation.

Alternative 2. Adoption of sustainable agricultural land management practices without considering incentives from the carbon revenues.

Alternative 3. Establishment of land with commercial tree plantation (Afforestation / Reforestation).

All the alternative land uses to the project activity as identified above are analyzed to be in compliance with all applicable legal and regulatory requirements in India.

Outcome of sub-step 1a: 3 alternative land use scenarios are considered which are in compliance with legal requirements within the project boundary.

Sub-step 1b. Consistency of credible alternative land use scenarios with enforced mandatory applicable laws and regulations

To demonstrate that identified alternatives to the ARR project activity are in compliance with all the applicable legal and regulatory requirements, and applicable Central and State Government laws and regulations. The list of laws and regulations has been analysed and have been considered while evaluating the alternatives to the project activity and all the following alternatives listed are in compliance with the applicable laws and regulations.

The identified alternatives are:

1. The continuation of the land-use and management existing prior to the implementation of the project activity with unsustainable practices may lead to the loss in soil nutrients and degradation.
2. Adoption of sustainable agricultural land management practices without considering incentives from the carbon revenues.
3. Establishment of land with commercial tree plantation (Afforestation / Reforestation).

The project activity is implemented on land belonging to the individual farmers and the status of land is private land. The legal title of the land parcels is held with individual farmers and is indicated through the land records issued by the local authority (Tahsildars) of the Karnataka state. Hence farmers are empowered to practice agricultural or tree planting practices of their choice on their lands.

There is no mandate regulations enforced in the state or country for all the 3-land use scenario identified and considered. Currently no laws and regulations prevent or enforce the project activity or the alternative land use scenarios.

1. Practising of Agriculture and planting of trees by farmers meets the objectives of the National Agroforestry policy, 2014 guidelines, National Mission on Sustainable Agriculture (2010) and the

organic farming Policies 2017 of the state government (Govt. of Karnataka). This is applicable for all alternative scenarios.

2. National policies such as National Mission for Sustainable Agriculture (NMSA) -The Ministry of Agriculture and Farmers Welfare, Government of India launched NMSA to promote sustainable agriculture. This is especially applicable for alternative scenario 2.
3. Regional policies such as Karnataka Organic Farming Policy 2017.

The state government launched the Karnataka Organic Farming Policy 2017, in order to enable the next level of development in Organic farming. The policy strategies included organic farming in mainstream agriculture, focus on region and season specific crops to increase farm output and income. However, there is no enforcement by this law for farmers to adopt organic agricultural practices and it is up to the discretion of farmers. Applicable for alternative scenario 2.

These regulations are only guidelines for continuation of farming activities in the region but not enforced or prevent the practices of SALM in the project area.

Outcome of sub-step 1b: Hence outcome of this step is all the three identified alternatives are credible and in compliance with host country laws. No mandate regulation enforcement for the adaptation of SALM practices in the project area.

Step 2: Barrier analysis

Sub-step 2a. Identification of barriers that would prevent the implementation of at least one alternative land use scenarios. If this step is used, determine whether the proposed project activity faces barriers that:

a) Prevent the implementation of this type of proposed project activity without the revenue from the sale of GHG credits.

and

b) Do not prevent the implementation of at least one of the alternative land use scenarios.

Following is list of the identified barrier

Table 7: Table showing identified barriers

Alternative land use scenarios	Barriers				
	Investment barrier	Institutional barrier	Technological barriers	Prevailing practice	Local traditions
The continuation of the land-use and management existing prior to the implementation of the project activity with unsustainable practices may lead to a loss in soil nutrients and degradation.					
Adoption of sustainable agricultural land management practices without considering incentives from the carbon revenues (Project Activity)	X	X	X		X
Establishment of land with commercial tree plantation (Afforestation / Reforestation).	X		X		

Outcome of Step 2a: Alternative 2 and alternative 3 are prevented by the barriers. The elimination of these barriers is supported in step 2b.

Sub-step 2b: Elimination of land use scenarios that are prevented by the identified barriers. The barriers that are considered which prevent alternatives 2 and 3 are:

The Below Table: displays the barrier analysis for the three identified alternative land use scenarios. The identified barriers are discussed in Sub-step 2b

Table 8: Table showing the barrier analysis for identified alternative land use scenarios

Alternative land use scenarios	Barriers				
	Investment Barrier	Institutional barrier	Technological barriers	Prevailing practice	Local traditions
The continuation of the land-use and management existing prior to the implementation of the project activity with unsustainable practices may lead to a loss in soil nutrients and degradation.					
Adoption of sustainable agricultural land management practices without considering incentives from the carbon revenues (Project Activity)	X	X	X		X

Establishment of land with commercial tree plantation (Afforestation / Reforestation).	X		X		
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Alternative 1: No Barriers

Alternative 2 Elimination:

Investment Barriers: Cost of organic farming is one of the main factors which constitute the investment barrier. According to a study in 2017 (Mohan Kumar et.al. 2017), ²⁰cost of production of organic ragi and maize per acre were Rs.24,817 and Rs.30,299 which is more than conventional farming i.e., Rs.17,128 and Rs. 21,655 respectively. Hence, it is almost 30% costlier compared to conventional farming. Also, organic agriculture is labor intensive, needs constant attention and skills, needs abundance of natural input material, and in transition periods (usually 2–3 years) often yield variations occur (Ramesh et al²¹., 2005, Prasad, 2005²²), no proper marketing access, agricultural infrastructure for organic produces. Other Investment Barriers including ²³

- **Lack of subsidies:** Organic farmers may not receive subsidies.
- **High input costs:** Organic farming is often more expensive than conventional farming
- **Shortage of biomass:** A shortage of essential nutrients in the soil due to extensive use of chemical fertilizers can lead to low productivity.

As farmers do not have access to funds for the initial investment to overcome, the barriers are justified.

Institutional barrier: In one of the research papers stated that in Karnataka the risk and uncertainty related to the conversion period, such as temporarily declining yields and the lack of experience and information, were mentioned as major constraints preventing in particular asset-poor households from adopting organic farming. To date, lack of institutional extension and educational material on organic agriculture require farmers to rely on their own knowledge and farmers' networks. This was highlighted as self-sufficiency in knowledge and expertise by knowledgeable farmers but might be a major source of risk and uncertainty for others.

- **Underdeveloped Supply chain:** The supply chain is underdeveloped and small, farmers located in hilly regions and tribal belts find it extremely difficult to access the market. There is a shortage of

²⁰ Mohan Kumar et.al. 2017

²¹ Ramesh, P., Singh, M., SubbaRao, A., 2005. Organic farming: its relevance to the Indian context. Curr. Sci. India 88 (4), 561–568

²² Prasad, R., 2005. Organic farming vis-à-vis modern agriculture. Curr. Sci. 89 (2), 252–254

warehouses and refrigerated vehicles, which leads to spoilage of products. Organic products must be stored separately from conventional products to avoid cross-contamination, and the existing supply chain does not often provide that facility. The government supports organic product marketing through fairs and exhibitions, but it does not give farmers a steady market. Direct linkages to processors and retailers will help farmers to get a better price, but farmers lack the right linkages and hence must depend on middlemen.

- **Industrial scale farming is difficult:** Many organic crops are grown in mono-cultures, like conventional crops, but use organically registered pesticides and fertilizers. It is common for organic growers to spray pesticides even more frequently than their conventional counterparts to keep up with insect and disease pressure. Organic methods are much more effective on a small scale than on the industrial level.

Further the prevalent practice is conventional farming using inorganic fertilizers which are heavily subsidized and are more accessible justifies the institutional barrier. The access to seedlings and/or tree saplings to adopt agroforestry practices also faces an institutional barrier as the farmer is not aware of the benefits or has access for the purchase of seedlings or tree saplings.

Technological Barriers: Further Lack of access to planting materials, constraining in using fertilizers, breakdown of the agricultural economy (including lack of seeds, agricultural credits, and agricultural equipment) are among the major technological barriers.

The most important barrier considered in the progress of organic agriculture in India/Karnataka was the lacunae in the government policies of making a firm decision to promote organic agriculture. Moreover, there were several major drawbacks in the growth of organic farming in India/Karnataka which include lack of awareness, lack of good marketing policies, shortage of biomass, inadequate farming infrastructure, high input cost of farming, inappropriate marketing of organic input, inefficient agricultural policies, lack of financial support, incapability of meeting export demand, lack of quality manure, and low yield (Bhardwaj and Dhiman, 2019²⁴).

Further in India and in the state of Karnataka large number of Farmers are not converting to organic because of:

- **Mindset of chemical-based farming - biggest barrier:** Key decision makers, even agricultural development machinery in general still not convinced about organic farming potential despite evidence pointing to contrary

²⁴ Growth and performance of organic farming in India: what could be the Future prospects, Journal of Current Science, Vol 20, No 01, January 2019

- **Marketing support, remunerative and fair price realization by farmers:** connecting to potential buyers, who could provide remunerative price is a serious issue
- **Availability of quality organic inputs:** lack of availability of suitable quality organic inputs like seeds, compost, inputs, natural or organic bio-pesticides Chemical inputs marketed aggressively, available easily and have proper distribution network and supply chain throughout the country with subsidy.
- **Chemical agri-input aggressive lobby:** Regulation of chemical inputs not stringent, marketing of chemical inputs very aggressive, input companies' agents usually have a heavy influence but similar supply chain missing with organic inputs.
- **Inadequate infrastructure:** Farmers may face poor roads and transportation facilities. On the other hand, India has a low number of processing plants and cold storage facilities, making it difficult to get produce to consumers
- **Bio-inputs industry is unregulated:** Still in nascent stage, serious quality concerns of available bio-input.
- **Lack of marketing and distribution network:** Bio-fertilizers and bio-pesticides may not be popular, and retailers may not be interested in dealing with them
- **Lack of 'evidence' to show that organic farming is viable:** Still results of organic farming's not well documented, un-verified in many cases, proper scientific validation

Local Tradition Barrier: Organic farming does not mean going 'back' to traditional methods. It is the integration of all sustainable approaches, found to fulfil the objectives of sustainable agriculture. In traditional India, the entire industry of agriculture was practiced using organic techniques, where the fertilizers and pesticides were obtained from plant and animal products. The Green Revolution (under the leadership of M. S. Swami Nathan) became the government's most important program in the 1960s. Several hectares of land were brought under cultivation. Hybrid seeds were introduced. Natural and organic Fertilizers were replaced by chemical fertilizers and locally made pesticides were replaced by chemical pesticides. In 1990s, India had surplus food grains and once again became an exporter of food grains. The extensive dependence on chemical farming has shown its many defects. The land is losing its fertility and is demanding larger quantities of fertilizers to be used. Pests are becoming immune, requiring the farmers to use strong pesticides. Both consumer and farmers are now gradually shifting back to organic farming in India because organic farming is healthier. But however, due to local and traditional technology preventing the extensive adaptation of organic agriculture because of the use of local seed materials, FYM not supply required nitrogen to plant and facing deficit of nutrients. Traditional equipment may not be sufficient to use for large-scale farming activities.

The scenario 2, which is the implementation of SALM practices has investment and institutional barriers and prevailing practice which create a barrier for its voluntary adoption by the farmers. Further, access to finance to implement the SALM practices also exists as there are no funding agencies to promote such

activities and most of such activities depend on grants and more prevalent on revenue from carbon credits market.

Alternative 3 elimination:

Investment Barrier: The main barriers to the adoption of agroforestry include a lack of awareness, knowledge, and tools for the adoption of agroforestry or other climate-smart initiatives. There is a lack of resources to support conversion to agroforestry. For example, farmers lack the money to buy seedlings with good germplasm, build ponds, construct wells to address water scarcity, and protect fields from grazing. For commercial tree plantations, it was analyzed from surveys that upfront costs are significant within the project area. Therefore, the high investment costs and long incubation period for financial returns acts as the major barrier for this alternative scenario.

Technological Barrier: Limited awareness, proper technology and knowledge about the benefits and techniques of agroforestry can be a barrier to adoption.

- **Policy and Institutional Support:** The absence of clear policies, incentives, and support mechanisms specific to agroforestry can act as a barrier to adoption. Inconsistent or fragmented policies across different government departments and agencies may not adequately address the needs and challenges of agroforestry practitioners.
- **Infrastructure and Technical Support:** Limited availability of necessary infrastructure, such as nurseries, tools, and equipment, can hinder the adoption of agroforestry practices. Additionally, inadequate technical support and extension services can limit farmers' ability to implement and manage agroforestry systems effectively.

Outcome of Sub-step 2b: The land use types that are not prevented by any barriers are as follows.

Alternative 1: Land use will continue as pre-project land use which is unsustainable conventional techniques which will lead to degradation of fertile crop land.

Sub-step 2c. Determination of baseline scenario.

"Is forestation without being registered as an A/R CDM project activity included in the list of land use scenarios that are not prevented by any barrier?" - Answer is "NO"

Applying the decision tree to the outcome of sub-step 2b, only one land use scenario is practical without any barriers and in compliance with the legal regulations of the region and country.

Alternative 1: The continuation of the land-use and management existing prior to the implementation of the project activity

Outcome of step 3: After passing the barrier the continuation existing land use is the baseline scenario.

Thus Alternative 1 is the baseline scenario.

3.5 Additionality

For the Demonstration and assessment of additionality the STEP 4 of the Tool “Combined tool to identify the baseline scenario and demonstrate additionality as above has been used.

Step 4: Common practice test

The SALM Project activity is in the geographical region of Karnataka to propose carbon credits. This project engages the farmer members which promote better implementation of the SALM practices continuously.

VGS has analysed initiatives which incorporate similar sustainable agricultural practices in state of Karnataka prior to the project start date. The analysis of the list as summarized in Appendix 3, indicates that these initiatives are comparable in terms of scale, but differ as they are commercial ventures which focus on specific produce which are supplied to the markets. Often, the revenue is influenced by market demand for specific types of produce, the majority being the Organic Certified produce. Also, there is no long-term contractual agreements with farmers to follow practices until project lifetime which in the case with VGS is assured up to 30-year period. Also, these projects differ from VGS as there is no MRV system in place which is certified, to ensure the monitoring requirements are met to fulfil the effectiveness of the implementation. In terms of intervention, no other initiative comprises of Agroforestry and Soil Organic Carbon monitoring which are the major initiatives that make the VGS project unique. Also, due to the commercial nature of the initiatives these have been in operation for more than 20 years and have not been certified for carbon credits. These initiatives focus on the yield and produce for the revenue, whereas in the case of VGS, it has developed a project for carbon credit certification, focusing on the effectiveness of the interventions and has invested considerable amount of expenditure to put in place monitoring systems to implement and operate the project and to ensure that a regular incentive reaches the farmers in the form of sales from carbon credits. Hence this makes the project not only unique in terms of sustainable interventions but also indicates that it is not a business-as-usual activity to operate such a large-scale project focused on interventions with no revenue from carbon credits.

Based on the analysis of the similar commercial initiatives implemented across Karnataka as indicated above, it is analysed that use of Organic inputs for farming is the major intervention which is similar to the current VERRA project developed by VGS. The 7-year government database which is available, from the period 2010 to 2017, prior to the start of the VGS project, indicates that the total organic farming area under cultivation has not increased significantly and the average increase is around 2000 hectares per year, majority of which has happened between 2011 to 2016.

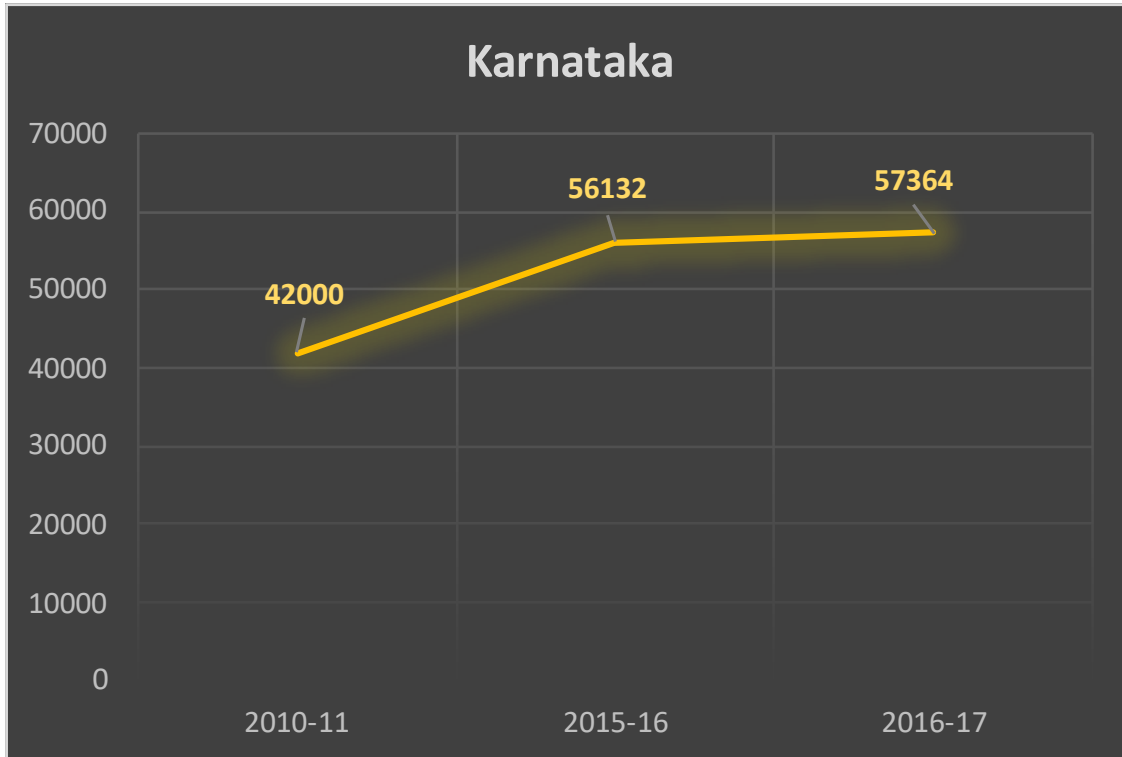


Figure 16: Crop area (Hectares) under organic farming in Karnataka

https://apeda.gov.in/apedawebsite/organic/data-Archive_2021-2022.htm#Total_farm_area_2022

<https://apeda.gov.in/apedawebsite/organic/data.htm>

Some of the reasons for the low level of implementation of organic farming practices which has faced have faced several challenges are as follows:

- a) **Poor Implementation:** While the state has implemented various policies and programs to promote organic farming, the execution and support provided to farmers have been inconsistent. The monitoring of the effectiveness of the implementation is also lacking.
- b) **Lack of Proper Training:** Farmers often lack the necessary knowledge and skills to transition to organic farming practices. Without adequate training, it becomes difficult for them to adopt and sustain organic methods.
- c) **Insufficient Financial Support:** The financial support provided to farmers is often inadequate to cover the costs associated with organic farming, such as certification, input costs, and market access.
- d) **Limited Market Access:** Farmers face challenges in accessing reliable and profitable markets for their organic produce. This lack of market linkages can hinder the growth of the organic sector.

These factors have collectively contributed to the challenges faced by Karnataka's organic farming projects, resulting in slower growth and limited impact compared to the state's potential.

While Karnataka's organic farming initiatives have faced challenges, it's important to acknowledge the unique aspects of the current VGS project. These projects seem to incorporate several best practices that can address the issues faced by previous initiatives.

Here are some key factors that differentiate the current VGS projects:

Comprehensive Approach:

- a) Agroforestry: This practice enhances biodiversity, soil health, and overall farm productivity.
- b) Continuous Capacity Building: Regular training sessions empower farmers with the latest knowledge and skills.
- c) Robust Monitoring: Close monitoring of project interventions helps identify challenges and implement timely solutions and improves overall effectiveness.
- d) Long term Sustainable Practices: Incorporating agroforestry and organic farming practices promotes long-term sustainability for the project lifetime.
- e) Sustainable Development Goals: These projects align with sustainable development goals, contributing to environmental and social well-being.

Many Government schemes change over a period due to change in the political scenario due to which effective implementation and monetary benefits are not implemented in a timely manner, and many times farmers may miss purchasing/implementing agricultural activities including purchase of seasonal seeds or inputs or plant agroforestry Spices. Due to changes in the scheme or restricted funds by local government, farmers are not encouraged to continue SALM activities. Secondly, no market guarantee for the produce grown with SALM activities is provided by the Government. There are many more challenges faced by my farming communities with government schemes or initiatives where farmers lost confidence. Therefore, SALM is not common practice.

The carbon incentives help the farmers to address the above-mentioned barriers and justify that this project is unique and hence is not common practice.

Conclusion: The proposed AFOLU SALM project activity is not the baseline scenario and, hence, it is additional.

3.6 Methodology Deviations

There is a deviation in applied methodology in this project. As per sections IV.1.1b and IV.2.4 of the applied methodology, it is recommended to use proper sampling standards to monitor the data/parameters for monitoring purposes. However, the full census for both the Fertilizer usage and Agroforestry has been conducted for this monitoring period (first monitoring). In accordance with the ABMS requirement of the methodology VM0017, a stratified random sampling approach will be adopted for future monitoring by application of CDM's General Guidelines for Sampling and Surveys for Small-Scale CDM Project Activities.

4 ESTIMATED GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

Baseline emissions were estimated based on the data recorded during VGS monitoring undertaken prior to October 2017 for the total project area. The baseline net GHG removals by sinks are estimated using equation 3 in section II (4.8) of the Approved VCS methodology VM0017 (version 1.0).

4.1.1 Baseline emissions due to fertilizer use

The baseline emissions from synthetic fertilizer, BEF_t , are calculated using the CDM A/R Tool: Estimation of direct nitrous oxide emission from nitrogen fertilization version 01. For the ex-ante assumptions, the adoption rate for the initial five years is considered to be 90%, with the adoption rate for the subsequent years set at 100%.

The direct nitrous oxide emissions from nitrogen fertilization can be estimated using equations as follows:

$$N_2O_{direct-N,t} = (F_{SN,t} + F_{ON,t}) \times EF_1 \times MW_{N_2O} \times GWP_{N_2O} \quad (1)$$

$$F_{SN,t} = \sum_i^I M_{SFi,t} \times NC_{SFi} \times (1 - Frac_{GASF}) \quad (2)$$

$$F_{ON,t} = \sum_j^J M_{OFj,t} \times NC_{OFj} \times (1 - F_{GASM}) \quad (3)$$

Where:

$N_2O_{direct-N,t}$	Direct N ₂ O emission as a result of nitrogen application within the project boundary, t-CO ₂ -e in year t
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x , t-N in year t
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x , t-N in year t
$M_{SFi,t}$	Mass of synthetic fertilizer type i applied tonne in year t
$M_{OFj,t}$	Mass of Number of synthetic fertilizer types organic fertilizer type j applied, tonne in year t
EF_1	Emission Factor for emissions from N inputs, tonne-N ₂ O-N (t-N input) ⁻¹
$Frac_{GASF}$	Fraction that volatilises as NH ₃ and NO _x for synthetic fertilizers, dimensionless
F_{GASM}	Fraction that volatilises as NH ₃ and NO _x for organic fertilizers, dimensionless
MW_{N_2O}	Ratio of molecular weights of N ₂ O and N (44/28), tonne-N ₂ O (t-N) ⁻¹
GWP_{N_2O}	Global Warming Potential for N ₂ O, kg-CO ₂ -e (kg-N ₂ O) ⁻¹ (IPCC default = 310, valid for the first commitment period)
NC_{SFi}	Nitrogen content of synthetic fertilizer type i applied, g-N (100 g fertilizer) ⁻¹

NC_{OFj}	Nitrogen content of organic fertilizer type j applied, g-N (100 g fertilizer) ⁻¹
I	Number of synthetic fertilizer types
J	Number of organic fertilizer types

Table 9: Data/Parameters used for estimation of the direct nitrous oxide emissions from nitrogen fertilization

Data/Parameter	Unit	Description	Sources	Value applied
EF1	t-N ₂ O-N	Emission Factor for emissions from N inputs	Country-specific data, IPCC	0.01 (Refer IPCC Table 11.1)
FracGASF	Dimensionless	The fraction that volatilizes as NH ₃ and NOX for synthetic fertilizers	Country-specific data, IPCC	0.11 (Refer IPCC Table 11.3)
FracGASM	Dimensionless	The fraction that volatilizes as NH ₃ and NOX for organic fertilizers	Country-specific data, IPCC	0.21 (Refer IPCC Table 11.3)
FSN,t	t-N yr ⁻¹	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NOX	Estimated	347 kg
FON,t	t-N yr ⁻¹	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NOX	Estimated	Nil
NCSFi	g-N (100 g fertilizer) ⁻¹	Nitrogen content of synthetic	Producers of synthetic fertilizer	0.4 ²⁵

²⁵ <https://sci-hub.arizonastockbroker.com/10.1023/a:1009740530221>

the direct emissions from agricultural soils have been estimated at 2.1 (0.4-3.8) Tg N y⁻¹, with a total from agricultural systems (including emissions from animal production and indirect emissions derived from N of agricultural origin) of 6.3 Tg N y⁻¹ (Mosier et al., 1998).

		fertilizer type i applied	purchased and used	
NCOFj	g-N (100 g fertilizer)-1	Nitrogen content of organic fertilizer type j applied	Organic fertilizer manufacturer, or determination in lab	0.2 ²⁶
MWN2O	tonne-N2O (t-N)-1	Ratio of molecular weights of N2O and N	IPCC default value	44/28
GWPN2O	kg-CO2-e (kg-N2O)-1	Global Warming Potential for N2O	IPCC default value	310

By applying equation 1

$$N2O_{direct-N,t} = 7.965 * 0.01 * (44/28) * 310 = 0.38 \text{ tCO}_2\text{e}$$

Synthetic fertilizer applied = 347 kg = 0.3 ton

By applying equation 2

$$FSN, t = 0.3 * 29.5 * (1 - 0.1) = 0.0783 \text{ t-N in year t}$$

By applying equation 3

$$FON, t = 0$$

Baseline emissions from inorganic fertilizer use were calculated using 2016 data, with an average rate of 0.30 tons per hectare. Using the CDM A/R tool for "Estimation of Direct Nitrous Oxide Emissions from Nitrogen Fertilization" and applying equations 1 and 2 from the tool, the annual greenhouse gas emissions due to fertilizer use in the baseline were determined to be 0.38 tons of CO2 equivalent per hectare of agricultural land per year. Consequently, the Baseline Emissions Factor (BEF) is 0.38 tons of CO2 equivalent per hectare per year.

Table 10: Ex-ante estimation of baseline emissions due to fertilizer use

t (years)	BEFt (tCO2e)
1st oct 2017	4,918
2018	19,670
2019	19,670
2020	19,670
2021	19,670
2022	19,670
2023	21,856
2024	21,856
2025	21,856

²⁶ Table: 2 - CURRENT IPCC DEFAULT METHOD FOR CALCULATING N2O EMISSIONS FROM DIRECT SOURCES

2026	21,856
2027	21,856
2028	21,856
2029	21,856
2030	21,856
2031	21,856
2032	21,856
2033	21,856
2034	21,856
2035	21,856
2036	21,856
2037	21,856
2038	21,856
2039	21,856
2040	21,856
2041	21,856
2042	21,856
2043	21,856
2044	21,856
2045	21,856
2046	21,856
30th Sept 2047	16,392

4.1.2 Baseline emissions due to the use of N-fixing species

As there is no baseline established for the use of N-fixing species, baseline emissions changes due to the use of N- fixing species are considered as zero, therefore:

$$BEN_t = 0$$

4.1.3 Baseline emissions due to burning of biomass

The project is promoting the cessation of biomass burning and thus emissions due to this practice are expected to decrease within the project as compared to the baseline emissions. Hence the emissions are based on the total crop residue subjected to burning and calculated by use of the emission factor as mandated by the methodology. The tool Estimation of non-CO₂ emissions from the burning of crop residues (Section VI.3 of the methodology) is applied to estimate the emissions from N₂O and CH₄. However, the project is not claiming emission reductions due to biomass burning and hence this is not monitored.

4.1.4 Baseline emissions from existing woody perennials

The baseline removals from woody perennials, BRWP t are calculated using the Tool Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities version 4.2.

Baseline trees are considered to be non-existent as the project is primarily a Cropland. Only new trees planted by the project will be considered in the project, hence the removals from existing woody perennials conservatively assumed to be zero.

$$\text{BRWP } t = 0$$

4.1.5 Baseline emissions from use of fossil fuels in agricultural management

As per the tool 'Estimation of emissions from combustion the use of fossil fuels in agricultural management' (Section VI.2 of the methodology) the baseline emission due to the use of fossil fuels which is insignificant compared to the project net anthropogenic GHG removals. Hence, these emissions are found to be insignificant and are assumed to be zero in the baseline scenario.

$$\text{BEFF } t = 0$$

4.1.6 Equilibrium soil organic carbon density in management systems

The baseline surveys conducted in 2016 and 2017 captured both the extent of SALM (Sustainable Agricultural Land Management) practices implemented and the data necessary to estimate model input parameters for calculating baseline equilibrium soil organic carbon (SOC) densities under existing management systems. As outlined in the methodology, the objective is not to determine the absolute SOC levels in the baseline, but rather to assess the changes—either increases or decreases—in SOC resulting from project interventions. SOC estimations linked to SALM practices should only be considered when there is a difference between baseline and project scenarios that would lead to SOC changes. This occurs in two key situations:

- When a model input parameter change (e.g., due to higher crop yields), or
- When the area under a given SALM practice changes (e.g., due to increased adoption).

In the RothC model, inputs from the past five years of weather data, along with crop residue and farmyard manure data, were used for 397 farmers across different SALM activities. These inputs were collected for each of the five agricultural seasons (kharif, kharif or rabi, kharif+Rabi+summer, perennial and Zaid seasons) across the respective IPCC zones during the 2016 and 2017 baseline period. The baseline scenario was then projected over a 30-year period. The model input parameters, along with their upper and lower confidence limits (Pmin, Pmax), are provided in Appendix 1 and are essential for estimating modelling uncertainty as per Section IV.2.8 of the SALM Methodology.

Table 11: IPCC wise Seasonal RothC modeled baseline equilibrium (30 years) soil organic carbon densities in tC/ha

Seasons	(30 years) Mean SOC tC/ha		
	Tropical dry	Tropical moist	Tropical wet
Kharif	20.89	20.43	17.71
Kharif / Rabi	21.66	20.34	16.84
Kharif / Rabi / Summer	22.98	16.97	15.19

Perennial	15.88	15.63	
Zaid/Summer	22.52	23.17	

The baseline soil organic carbon at equilibrium which is estimated is summarized as below :

$$BS_{equil,t} = \sum_{m_c} BA_{C,m_c,t} \times SOC_{C,m_c} + \sum_{m_G} BA_{G,m_G,t} \times SOC_{G,m_G} \quad (1)$$

Where:

$BS_{equil,t}$	Baseline SOC in equilibrium year t, tC
$BA_{C,m_c,t}$	Baseline areas in cropland with management practices, m_c , year t, ha
SOC_{C,m_c}	Soil organic carbon density at equilibrium for cropland with management practices, m_c , tC/ha
m_c	An index for cropland management types, unit less
$BA_{G,m_G,t}$	Baseline areas in grassland with management practices, m_G , year t, ha
SOC_{G,m_G}	Soil organic carbon density to a depth of 30 cm, at equilibrium for grassland with management practice, m_G , tC/ha
m_G	An index for grassland management types, unit less

4.1.7 Baseline removals due to change in soil organic carbon

The degradation assessment outlined in Section 3.2 also demonstrates that the project areas “are constantly degraded/ degrading”. Hence, SOC in the baseline can be expected to decrease or at most remain in a steady state. As per VCS SALM Methodology, the applicability conditions limit the project to lands that are under agricultural pressure and are degrading. It can be conservatively assumed that the baseline removals due to changes in SOC are zero.

Therefore, for ex-ante estimation, it is accounted as zero

$$BRSt = 0$$

The total baseline emissions and removals are given by:

$$BE_t = BEF_t + BEFF_t + BEBB_t - BRWP_t$$

Where

BE_t Baseline emission in year t, t CO₂e

BEF_t Baseline emission due to nitrogen fertilizer use in year t, t CO₂e

$BEFF_t$ Baseline emission due to use of fossil fuels in agricultural management in year t, t CO₂e

$BEBB_t$ Baseline emission due to biomass burning in year t, t CO₂e

$BRWP_t$ Baseline removals due to changes in woody perennials in year t, t CO₂e

Table 12: : Baseline GHG emissions and removals by sinks

t (year)	Total area (ha)	BEF _t (tCO ₂ e)	BEN _t (tCO ₂ e)	BEBB _t (tCO ₂ e)	BRWP _t (tCO ₂ e)	BEFF _t (tCO ₂ e)	BRS _t (tCO ₂ e)	BE _t (tCO ₂ e)
1st oct 2017	51,764.40	4,918	0	0	0	0	0	4,918
2018	51,764.40	19,670	0	0	0	0	0	19,670
2019	51,764.40	19,670	0	0	0	0	0	19,670
2020	51,764.40	19,670	0	0	0	0	0	19,670
2021	51,764.40	19,670	0	0	0	0	0	19,670
2022	51,764.40	19,670	0	0	0	0	0	19,670
2023	57,516.00	21,856	0	0	0	0	0	21,856
2024	57,516.00	21,856	0	0	0	0	0	21,856
2025	57,516.00	21,856	0	0	0	0	0	21,856
2026	57,516.00	21,856	0	0	0	0	0	21,856
2027	57,516.00	21,856	0	0	0	0	0	21,856
2028	57,516.00	21,856	0	0	0	0	0	21,856
2029	57,516.00	21,856	0	0	0	0	0	21,856
2030	57,516.00	21,856	0	0	0	0	0	21,856
2031	57,516.00	21,856	0	0	0	0	0	21,856
2032	57,516.00	21,856	0	0	0	0	0	21,856
2033	57,516.00	21,856	0	0	0	0	0	21,856
2034	57,516.00	21,856	0	0	0	0	0	21,856
2035	57,516.00	21,856	0	0	0	0	0	21,856
2036	57,516.00	21,856	0	0	0	0	0	21,856
2037	57,516.00	21,856	0	0	0	0	0	21,856
2038	57,516.00	21,856	0	0	0	0	0	21,856
2039	57,516.00	21,856	0	0	0	0	0	21,856
2040	57,516.00	21,856	0	0	0	0	0	21,856
2041	57,516.00	21,856	0	0	0	0	0	21,856
2042	57,516.00	21,856	0	0	0	0	0	21,856
2043	57,516.00	21,856	0	0	0	0	0	21,856
2044	57,516.00	21,856	0	0	0	0	0	21,856
2045	57,516.00	21,856	0	0	0	0	0	21,856
2046	57,516.00	21,856	0	0	0	0	0	21,856
30th Sept 2047	57,516.00	16,392	0	0	0	0	0	16,392

4.2 Project Emissions

Project emissions due to fertilizer use

A/R Methodological tool 07 “Estimation of direct nitrous oxide emission from nitrogen fertilization” (Version 01)

The direct nitrous oxide emissions from nitrogen fertilization can be estimated using equations as follows:

$$N_2O_{direct-N,t} = (F_{SN,t} + F_{ON,t}) \times EF_1 \times MW_{N_2O} \times GWP_{N_2O} \quad (1)$$

$$F_{SN,t} = \sum_i^I M_{SFi,t} \times NC_{SFi} \times (1 - Frac_{GASF}) \quad (2)$$

$$F_{ON,t} = \sum_j^J M_{OFj,t} \times NC_{OFj} \times (1 - F_{GASM}) \quad (3)$$

Where:

$N_2O_{direct-N,t}$	Direct N ₂ O emission as a result of nitrogen application within the project boundary, t-CO ₂ -e in year t
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x , t-N in year t
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x , t-N in year t
$M_{SFi,t}$	Mass of synthetic fertilizer type i applied tonne in year t
$M_{OFj,t}$	Mass of Number of synthetic fertilizer types organic fertilizer type j applied, tonne in year t
EF_1	Emission Factor for emissions from N inputs, tonne-N ₂ O-N (t-N input) ⁻¹
$Frac_{GASF}$	Fraction that volatilises as NH ₃ and NO _x for synthetic fertilizers, dimensionless
F_{GASM}	Fraction that volatilises as NH ₃ and NO _x for organic fertilizers, dimensionless
MW_{N_2O}	Ratio of molecular weights of N ₂ O and N (44/28), tonne-N ₂ O (t-N) ⁻¹
GWP_{N_2O}	Global Warming Potential for N ₂ O, kg-CO ₂ -e (kg-N ₂ O) ⁻¹ (IPCC default = 310, valid for the first commitment period)
NC_{SFi}	Nitrogen content of synthetic fertilizer type i applied, g-N (100 g fertilizer) ⁻¹
NC_{OFj}	Nitrogen content of organic fertilizer type j applied, g-N (100 g fertilizer) ⁻¹
I	Number of synthetic fertilizer types
J	Number of organic fertilizer types

Table 13: Data/Parameters used for estimation of the direct nitrous oxide emissions

Data/Parameter	Unit	Description	Sources	Value applied
EF1	t-N ₂ O-N	Emission Factor for emissions from N inputs	Country-specific data, IPCC	0.01 (Refer IPCC Table 11.1)
FracGASF	Dimensionless	The fraction that volatilizes as NH ₃ and NO _x for synthetic fertilizers	Country-specific data, IPCC	0.11 (Refer IPCC Table 11.3)

FracGASM	Dimensionless	The fraction that volatilizes as NH ₃ and NO _x for organic fertilizers	Country-specific data, IPCC	0.21 (Refer IPCC Table 11.3)
FSN,t	t-N yr ⁻¹	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x	Estimated	347 kg
FON,t	t-N yr ⁻¹	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x	Estimated	Nil
NCSFi	g-N (100 g fertilizer) ⁻¹	Nitrogen content of synthetic fertilizer type i applied	Producers of synthetic fertilizer purchased and used	0.4 (source: IPCC)
NCOFj	g-N (100 g fertilizer) ⁻¹	Nitrogen content of organic fertilizer type j applied	Organic fertilizer manufacturer, or determination in lab	0.2 (source: https://www.ipcc-nggip.iges.or.jp/public/gp/bgpp/4_5_N2O_Agricultural_Soils.pdf)
MWN2O	tonne-N2O (t-N) ⁻¹	Ratio of molecular weights of N ₂ O and N	IPCC default value	44/28
GWPN2O	kg-CO ₂ -e (kg-N ₂ O) ⁻¹	Global Warming Potential for N ₂ O	IPCC default value	310

By applying equation 1

$$N_{2O}direct-N,t = 7.965 * 0.01 * (44/28) * 310 = 0.38 \text{ tCO}_2e$$

$$\text{Synthetic fertilizer applied} = 347 \text{ kg} = 0.3 \text{ ton}$$

By applying equation 2

$$FSN, t = 0.3 * 29.5 * (1 - 0.1) = 0.0783 \text{ t-N in year } t$$

By applying equation 3

$$FON, t = 0$$

The project does not promote the use of synthetic fertilizers; instead, it encourages the adoption of SALM practices, which are expected to enhance soil fertility and reduce reliance on synthetic fertilizers. In the baseline scenario, the application of synthetic fertilizers was documented, with resulting emissions calculated at 0.38 tCO₂e per hectare of agricultural land per year.

- 1) Under the project scenario, both the necessity for synthetic fertilizers and their application rates are anticipated to decrease due to the implementation of soil fertility-enhancing SALM practices. However, for ex-ante estimation, the same emission rate as the baseline—0.38 tCO₂e per hectare of agricultural land per year—has been assumed. The crop area for 3 IPCC zones of 51,764 hectares accounting for final PEF t calculation. The ex-ante estimates are provided in the table below. The adoption rate for the initial five years is considered to be 90%, with the adoption rate for the subsequent years set at 100%

Therefore, for ex-ante estimation, is the emission factor is accounted as

$$\text{PEF t} = 0.38 \text{ tCO}_2\text{e}$$

Table 14: Total crop area covered by IPCC zones

IPCC	Crop Area (ha)
Tropical Dry	42,420
Tropical Moist	8,477
Tropical Wet	867
Total	51,764

Table 15: Ex-ante estimation of project emissions due to fertilizer use in Tropical dry zone

Tropical Dry		
Year	Crop area (ha)	PEFt (A)
1st oct 2017	38,178	3,627
2018	38,178	14,508
2019	38,178	14,508
2020	38,178	14,508
2021	38,178	14,508
2022	38,178	14,508
2023	42,420	16,120
2024	42,420	16,120
2025	42,420	16,120
2026	42,420	16,120
2027	42,420	16,120
2028	42,420	16,120
2029	42,420	16,120
2030	42,420	16,120
2031	42,420	16,120
2032	42,420	16,120
2033	42,420	16,120
2034	42,420	16,120
2035	42,420	16,120

2036	42,420	16,120
2037	42,420	16,120
2038	42,420	16,120
2039	42,420	16,120
2040	42,420	16,120
2041	42,420	16,120
2042	42,420	16,120
2043	42,420	16,120
2044	42,420	16,120
2045	42,420	16,120
2046	42,420	16,120
30th Sept 2047	42,420	12,090

Table 16: Ex-ante estimation of project emissions due to fertilizer use in Tropical moist zone

Tropical Moist		
Year	Crop area (ha)	PEFt (A)
1st oct 2017	7,630	725
2018	7,630	2,899
2019	7,630	2,899
2020	7,630	2,899
2021	7,630	2,899
2022	7,630	2,899
2023	8,477	3,221
2024	8,477	3,221
2025	8,477	3,221
2026	8,477	3,221
2027	8,477	3,221
2028	8,477	3,221
2029	8,477	3,221
2030	8,477	3,221
2031	8,477	3,221
2032	8,477	3,221
2033	8,477	3,221
2034	8,477	3,221
2035	8,477	3,221
2036	8,477	3,221
2037	8,477	3,221
2038	8,477	3,221
2039	8,477	3,221
2040	8,477	3,221
2041	8,477	3,221
2042	8,477	3,221
2043	8,477	3,221
2044	8,477	3,221

2045	8,477	3,221
2046	8,477	3,221
30th Sept 2047	8,477	2,416

Table 17: Ex-ante estimation of project emissions due to fertilizer use in Tropical wet zone

Tropical Wet		
Year	Crop area (ha)	PEFt (A)
1st oct 2017	780	74
2018	780	297
2019	780	297
2020	780	297
2021	780	297
2022	780	297
2023	867	329
2024	867	329
2025	867	329
2026	867	329
2027	867	329
2028	867	329
2029	867	329
2030	867	329
2031	867	329
2032	867	329
2033	867	329
2034	867	329
2035	867	329
2036	867	329
2037	867	329
2038	867	329
2039	867	329
2040	867	329
2041	867	329
2042	867	329
2043	867	329
2044	867	329
2045	867	329
2046	867	329
30th Sept 2047	867	247

Table 18: Total ex-ante estimation of project emissions due to fertilizer use in 3 IPCC zones

t (years)	Total crop area (ha)	PEFt (A+B+C) (tCO2e)
1st oct 2017	46,588	4,426

2018	46,588	17,703
2019	46,588	17,703
2020	46,588	17,703
2021	46,588	17,703
2022	46,588	17,703
2023	51,764	19,670
2024	51,764	19,670
2025	51,764	19,670
2026	51,764	19,670
2027	51,764	19,670
2028	51,764	19,670
2029	51,764	19,670
2030	51,764	19,670
2031	51,764	19,670
2032	51,764	19,670
2033	51,764	19,670
2034	51,764	19,670
2035	51,764	19,670
2036	51,764	19,670
2037	51,764	19,670
2038	51,764	19,670
2039	51,764	19,670
2040	51,764	19,670
2041	51,764	19,670
2042	51,764	19,670
2043	51,764	19,670
2044	51,764	19,670
2045	51,764	19,670
2046	51,764	19,670
30th Sept 2047	51,764	14,753

Project emissions due to the burning of fossil fuels

Estimate of project emissions due to burning of fossil fuels for agricultural management in year t , t CO₂e: As there is no net increase in the use of fossil fuels used for farm machinery during project implementation, it is not considered. The evidence has been submitted to VVB.

Therefore, for ex-ante estimation, it is accounted as zero.

PEFF $t=0$

Project emissions due to the use of N-fixing species

Estimate of project emissions due to the increased use of N-fixing species in year t , t CO₂e: As it is not considered in the project activity, it is not applicable.

Therefore, for ex-ante estimation, it is accounted as zero.

PEN t = 0

Project emissions due to the burning of biomass

Estimate of project emissions due to biomass burning in year t, t CO₂e: As the project activity does not consider any emission reductions from avoidance of biomass burning, it is not applicable.

Therefore, for ex-ante estimation, it is accounted as zero.

PEFF t= 0

Project removals from woody perennials

Estimate of project removals due to changes in biomass of woody perennials in year t, t CO₂e: the changes in the agroforestry trees are measured and the change in biomass calculated using the latest version of the CDM A/R tool: Estimation of carbon stocks of trees and shrubs in A/R CDM project activities.

The following equations were used based on the Tool 14:

$$C_{TREE} = \frac{44}{12} \times CF_{TREE} \times B_{TREE} \quad (\text{Equation 12})$$

$$B_{TREE} = A \times b_{TREE} \quad (\text{Equation 13})$$

$$b_{TREE} = \sum_{i=1}^M W_i \times b_{TREE,i} \quad (\text{Equation 14})$$

C_{TREE} = Carbon stock in trees in the tree biomass estimation strata; t CO₂e

CF_{TREE} = Carbon fraction of tree biomass; t C (t d.m.)⁻¹. A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value.

B_{TREE} = Tree biomass in the tree biomass estimation strata; t d.m.

A = Sum of areas of the tree biomass estimation strata; ha

b_{TREE} = Mean tree biomass per hectare in the tree biomass estimation strata; t d.m. ha⁻¹

W_i = Ratio of the area of stratum i to the sum of areas of tree biomass estimation strata (i.e./); dimensionless

$b_{TREE,i}$ = Mean tree biomass per hectare in stratum i; t d.m. ha⁻¹

The agroforestry area of 5,752 hectares was considered for PRWP t calculation based on the project design which is based on consideration of overall 10% of the total eligible farm area.

For the ex-ante estimates, the adoption rate for the initial five years is considered to be 90%, with the adoption rate for the subsequent years set at 100%.

0.5CM increase per year from 5th year onwards corresponds to approximately 1% increase of tree circumference which is widely used conservative estimate for tree growth.

Note: The source for the allometric equations used is based on the document published by FAO, accessible at <https://www.fao.org/4/W4095E/w4095e06.htm#:~:text=The%20first%20approach%20is%20based%20on%20the%20use,directly%20estimates%20biomass%20density%20using%20biomass%20regression%20equations.>

Table 19: Ex-ante estimates for project removals from woody perennials in Tropical dry zone

Tropical Dry		
Year	Agroforestry area (ha)	PRWPt (A)
1st oct 2017	3,870	0
2018	3,870	897
2019	3,870	4477
2020	3,870	11469
2021	3,870	22355
2022	3,870	37515
2023	4,300	38612
2024	4,300	39727
2025	4,300	40860
2026	4,300	42012
2027	4,300	43181
2028	4,300	44369
2029	4,300	45575
2030	4,300	46799
2031	4,300	48043
2032	4,300	49304
2033	4,300	50584
2034	4,300	51883
2035	4,300	53201
2036	4,300	54538
2037	4,300	55893
2038	4,300	57268
2039	4,300	58661
2040	4,300	60074
2041	4,300	61506
2042	4,300	62957
2043	4,300	64427
2044	4,300	65916
2045	4,300	67425
2046	4,300	68954
30th Sept 2047	4,300	52876

Table 20: Ex-ante estimates for project removals from woody perennials in Tropical moist zone

Tropical Moist		
Year	Agroforestry area (ha)	PRWPt (B)
1st oct 2017	784	0
2018	784	178
2019	784	1027
2020	784	2866
2021	784	5934
2022	784	10436
2023	871	10769
2024	871	11109
2025	871	11455
2026	871	11807
2027	871	12166
2028	871	12531
2029	871	12903
2030	871	13282
2031	871	13667
2032	871	14059
2033	871	14458
2034	871	14863
2035	871	15275
2036	871	15694
2037	871	16120
2038	871	16553
2039	871	16992
2040	871	17439
2041	871	17893
2042	871	18354
2043	871	18821
2044	871	19297
2045	871	19779
2046	871	20268
30th Sept 2047	871	15574

Table 21: Ex-ante estimates for project removals from woody perennials in Tropical wet zone

Tropical Wet		
Year	Agroforestry area (ha)	PRWPt (C)
1st oct 2017	79	0
2018	79	16
2019	79	93
2020	79	261
2021	79	539

2022	79	949
2023	87	979
2024	87	1010
2025	87	1041
2026	87	1073
2027	87	1106
2028	87	1139
2029	87	1173
2030	87	1207
2031	87	1242
2032	87	1278
2033	87	1314
2034	87	1351
2035	87	1388
2036	87	1427
2037	87	1465
2038	87	1505
2039	87	1545
2040	87	1585
2041	87	1626
2042	87	1668
2043	87	1711
2044	87	1754
2045	87	1798
2046	87	1842
30th Sept 2047	87	1416

Table 22: Total Ex-ante estimates for project removals from woody perennials in 3 IPCC zones

t (years)	Total agroforestry area (ha)	PRWP t (A+B+C)(tCO ₂ e)
1st oct 2017	4,733	0
2018	4,733	913
2019	4,733	4,570
2020	4,733	11,729
2021	4,733	22,895
2022	4,733	38,464
2023	5,258	39,591
2024	5,258	40,737
2025	5,258	41,902
2026	5,258	43,085
2027	5,258	44,287
2028	5,258	45,508
2029	5,258	46,748
2030	5,258	48,007

2031	5,258	49,285
2032	5,258	50,582
2033	5,258	51,899
2034	5,258	53,234
2035	5,258	54,590
2036	5,258	55,964
2037	5,258	57,359
2038	5,258	58,772
2039	5,258	60,206
2040	5,258	61,659
2041	5,258	63,132
2042	5,258	64,625
2043	5,258	66,138
2044	5,258	67,670
2045	5,258	69,223
2046	5,258	70,796
30th Sept 2047	5,258	54,292

Project equilibrium soil organic carbon density in management systems

Among all SALM management practices promoted by the project the only Residue management – including both residue mulching and cover crops is considered for soil organic carbon (SOC) estimations:

The RothC soil organic carbon model was used for SOC estimations. The baseline survey in 2016-2017 cropping season recorded the area of implementation of these practices in the baseline as well as the data required for the estimation of the corresponding model input parameters.

As stated in the methodology the goal is not the estimation of the absolute SOC in the baseline, but the estimation of the increase or decrease in SOC within the project. SALM practices need to be considered for SOC estimations only when differences between baseline and project scenarios will result in SOC changes. This happens in two cases:

- The model input parameter is changing (e.g. due to increasing yields).
- The area under the SALM practice is changing (e.g. due to increasing adoption).

In case of the project, the model input parameters have been changed because of the variation in the crop residue inputs.

Soil model input parameters

The RothC soil organic carbon model is used for SOC change calculations. The model input parameter for the different SALM practices is derived as follows using the annual ABMS data. All input parameters are calculated in relation to the entire adoption area, i.e. the total project area represented by the total cropland in each year of the monitoring period.

The total residue carbon from these crops is already adjusted with the percentage areas where residues are left on the field as mulch based on the annual ABMS data. The residues taken for other uses such as

composting, cooking, livestock feeding, or burning are therefore not considered. This adjusted input value for mulching is then used in the RothC modelling of soil carbon sequestration and then applied to the crop specific area shares of the entire project area, i.e., the total cropland. In addition, the model input parameters with the upper and lower confidence levels (Pmin, Pmax) which are applied to estimate the uncertainty of the soil modeling (see section IV.2.8 of the SALM Methodology) are also calculated.

For the ex-ante estimation, SOC changes from published literature²⁷ were used, reflecting net SOC changes based on the adoption of specific practices. T4 (100% NPK + Paddy Straw) was selected for SOC change because it effectively captures our intervention and incorporates Plant Input to model the SOC.

Project removals due to changes in soil organic carbon

For the ex-ante estimation, SOC changes from published literature were used (adopted from Bhattacharyya et al. 2013, modelled SOC for 0-13 cm and 13-23 cm soil depth) reflecting net SOC changes based on the adoption of specific practices. Average of T3, T4 and T5 was selected for SOC change as the study area represents more than 75% of the Project area. See Table 25 below for the SOC GHG removal values applied.

Table 23: Total organic carbon (modelled) for 0-13 cm soil depth from 1986-2004

TOC (modelled)		
0-13cm soil depth		
1986	2004	Difference (tCha-1)
16.15	22.72	6.57
17.4	21.91	4.51
17.44	23.54	6.1

Table 24: Total organic carbon (modelled) for 13-23 cm soil depth from 1986-2004

13-23cm soil depth		
1986	2004	Difference (tCha-1)
11.47	18.32	6.85
12.63	18.17	5.54
12.53	18.06	5.53

Table 25: Ex-ante soil organic carbon removal factor

Total	Average	Annual (tCha-1)	Annual (tCo2eq)
13.42	11.7	0.65	2.39
10.05			
11.63			

²⁷

https://www.researchgate.net/publication/274546754_Simulating_change_in_soil_organic_carbon_in_two_long_term_fertilizer_experiments_in_India_with_the_Roth_C_model

The crop area for 3 IPCC zones of 51,764 hectares accounting for final PRSt calculation.

The adoption rate for the initial five years is considered to be 90%, with the adoption rate for the subsequent years set at 100%

Ex-ante soil organic carbon removal factor applied is

PRSt (tCO₂e/ha/year) = 2.39

Table 26: Total crop area covered by 3 IPCC zones

IPCC	Crop Area (ha)
Tropical Dry	42,420
Tropical Moist	8,477
Tropical Wet	867
Total	51,764

Table 27: Ex-ante project removals due to changes in SOC in Tropical dry zone

Tropical Dry		
Year	Crop area (ha)	PRSt (A)
1st oct 2017	38,178	22,768
2018	38,178	91,074
2019	38,178	91,074
2020	38,178	91,074
2021	38,178	91,074
2022	38,178	91,074
2023	42,420	101,193
2024	42,420	101,193
2025	42,420	101,193
2026	42,420	101,193
2027	42,420	101,193
2028	42,420	101,193
2029	42,420	101,193
2030	42,420	101,193
2031	42,420	101,193
2032	42,420	101,193
2033	42,420	101,193
2034	42,420	101,193
2035	42,420	101,193
2036	42,420	101,193
2037	42,420	101,193
2038	42,420	101,193
2039	42,420	101,193
2040	42,420	101,193

2041	42,420	101,193
2042	42,420	101,193
2043	42,420	101,193
2044	42,420	101,193
2045	42,420	101,193
2046	42,420	101,193
30th Sept 2047	42,420	75,895

Table 28: Ex-ante project removals due to changes in SOC in Tropical moist zone

Tropical Moist		
Year	Crop area (ha)	PRSt (B)
1st oct 2017	7,630	4,550
2018	7,630	18,200
2019	7,630	18,200
2020	7,630	18,200
2021	7,630	18,200
2022	7,630	18,200
2023	8,477	20,223
2024	8,477	20,223
2025	8,477	20,223
2026	8,477	20,223
2027	8,477	20,223
2028	8,477	20,223
2029	8,477	20,223
2030	8,477	20,223
2031	8,477	20,223
2032	8,477	20,223
2033	8,477	20,223
2034	8,477	20,223
2035	8,477	20,223
2036	8,477	20,223
2037	8,477	20,223
2038	8,477	20,223
2039	8,477	20,223
2040	8,477	20,223
2041	8,477	20,223
2042	8,477	20,223
2043	8,477	20,223
2044	8,477	20,223
2045	8,477	20,223
2046	8,477	20,223
30th Sept 2047	8,477	15,167

Table 29: Ex-ante project removals due to changes in SOC in Tropical wet zone

Tropical Wet		
Year	Crop area (ha)	PRSt (C)
1st oct 2017	780	465
2018	780	1,862
2019	780	1,862
2020	780	1,862
2021	780	1,862
2022	780	1,862
2023	867	2,068
2024	867	2,068
2025	867	2,068
2026	867	2,068
2027	867	2,068
2028	867	2,068
2029	867	2,068
2030	867	2,068
2031	867	2,068
2032	867	2,068
2033	867	2,068
2034	867	2,068
2035	867	2,068
2036	867	2,068
2037	867	2,068
2038	867	2,068
2039	867	2,068
2040	867	2,068
2041	867	2,068
2042	867	2,068
2043	867	2,068
2044	867	2,068
2045	867	2,068
2046	867	2,068
30th Sept 2047	867	1,551

Table 30: Total ex-ante project removals due to changes in SOC in 3 IPCC zones

t (years)	Total crop area (ha)	PRSt (A+B+C) (tCO₂e)
1st oct 2017	46,588	27,784
2018	46,588	111,136
2019	46,588	111,136
2020	46,588	111,136
2021	46,588	111,136
2022	46,588	111,136
2023	51,764	123,484
2024	51,764	123,484

2025	51,764	123,484
2026	51,764	123,484
2027	51,764	123,484
2028	51,764	123,484
2029	51,764	123,484
2030	51,764	123,484
2031	51,764	123,484
2032	51,764	123,484
2033	51,764	123,484
2034	51,764	123,484
2035	51,764	123,484
2036	51,764	123,484
2037	51,764	123,484
2038	51,764	123,484
2039	51,764	123,484
2040	51,764	123,484
2041	51,764	123,484
2042	51,764	123,484
2043	51,764	123,484
2044	51,764	123,484
2045	51,764	123,484
2046	51,764	123,484
30th Sept 2047	51,764	92,613

Monitoring of input parameters for SOC

The project area is stratified according to the major soil orders, specifically Alfisols, Inceptisols, Entisols, Vertisols, Aridisols, and Ultisols, to facilitate the monitoring and analysis of Soil Organic Carbon (SOC) changes over time. The stratification ensures a comprehensive understanding of SOC dynamics across different soil types, which may exhibit varying organic carbon content and responsiveness to environmental factors.

Input parameters required for the modelling of SOC change, such as climate data, land use, soil properties, and agricultural management practices, are collected annually. The monitored ABMS sheets have been submitted to the VVB. These parameters will serve as key inputs for the model, which is designed to simulate and track increase or decrease in SOC.

As per the project design and based on methodology, SOC change will be modelled and analysed at five-year intervals, allowing for the assessment of medium-term trends and impacts within each soil order. This periodic monitoring, combined with annual data collection and stratified soil analysis, provides a comprehensive framework for understanding and predicting SOC changes, contributing to more effective land management and climate mitigation strategies.

The full ex-post SOC accounting and modelling approach (refer **Appendix 1**) is further detailed under section 6.3 for the first monitoring period.

Total ex ante project net GHG emissions and removals by sinks

The actual net GHG removals by sinks are estimated using the equation in section III (1.9) of the Approved VCS methodology VM0017 (Version 1.0). The actual net GHG removals by sinks are calculated using equation 7 of the methodology.

$$PE_t = PEF_t + PEFF_t + PEN_t + PEBB_t - PRWP_t - PRS_t$$

Where

PE_t Estimate of actual net project GHG emissions and removals by sinks in year t, t CO₂e

PEF_t Estimate of project emissions due to nitrogen fertilizer use in year t, t CO₂e

$PEFF_t$ Estimate of project emissions due to burning of fossil fuels for agricultural management in year t, t CO₂e

PEN_t Estimate of project emissions due to the increased use of N-fixing species in year t, t CO₂e

$PEBB_t$ Estimate of project emissions due to biomass burning in year t, t CO₂e

$PRWP_t$ Estimate of project removals due to changes in biomass of woody perennials in year t, t CO₂e

PRS_t Estimate of project removals due to change in soil organic carbon in year t, t CO₂e.

Table 31: Crop area and agroforestry area accounting for estimation of ex-ante GHG emissions and removals by sinks

IPCC Zone	Crop area (ha)	Agroforestry area (ha)	Total area (ha)
Tropical Dry	42,420	4,713	57,516
Tropical Moist	8,477	942	
Tropical Wet	867	96	
Sum of the area	51,764	5,752	

Table 32: Total ex-ante net project GHG emissions and removals by sinks

t (year)	Total area (ha)	PEF _t	PEN _t	PEBB _t	PRWP _t	PEFF _t	PRSt	PE _t
1st oct 2017	51,764.40	4,426	0	0	0	0	27,784	-23,358
2018	51,764.40	17,703	0	0	913	0	111,136	-94,345
2019	51,764.40	17,703	0	0	4,570	0	111,136	-98,003
2020	51,764.40	17,703	0	0	11,729	0	111,136	-105,162
2021	51,764.40	17,703	0	0	22,895	0	111,136	-116,327
2022	51,764.40	17,703	0	0	38,464	0	111,136	-131,896
2023	57,516.00	19,670	0	0	39,591	0	123,484	-143,405
2024	57,516.00	19,670	0	0	40,737	0	123,484	-144,551
2025	57,516.00	19,670	0	0	41,902	0	123,484	-145,715
2026	57,516.00	19,670	0	0	43,085	0	123,484	-146,898

2027	57,516.00	19,670	0	0	44,287	0	123,484	-148,100
2028	57,516.00	19,670	0	0	45,508	0	123,484	-149,321
2029	57,516.00	19,670	0	0	46,748	0	123,484	-150,561
2030	57,516.00	19,670	0	0	48,007	0	123,484	-151,820
2031	57,516.00	19,670	0	0	49,285	0	123,484	-153,098
2032	57,516.00	19,670	0	0	50,582	0	123,484	-154,396
2033	57,516.00	19,670	0	0	51,899	0	123,484	-155,712
2034	57,516.00	19,670	0	0	53,234	0	123,484	-157,048
2035	57,516.00	19,670	0	0	54,590	0	123,484	-158,403
2036	57,516.00	19,670	0	0	55,964	0	123,484	-159,778
2037	57,516.00	19,670	0	0	57,359	0	123,484	-161,172
2038	57,516.00	19,670	0	0	58,772	0	123,484	-162,586
2039	57,516.00	19,670	0	0	60,206	0	123,484	-164,019
2040	57,516.00	19,670	0	0	61,659	0	123,484	-165,472
2041	57,516.00	19,670	0	0	63,132	0	123,484	-166,945
2042	57,516.00	19,670	0	0	64,625	0	123,484	-168,438
2043	57,516.00	19,670	0	0	66,138	0	123,484	-169,951
2044	57,516.00	19,670	0	0	67,670	0	123,484	-171,484
2045	57,516.00	19,670	0	0	69,223	0	123,484	-173,037
2046	57,516.00	19,670	0	0	70,796	0	123,484	-174,610
30th Sept 2047	57,516.00	14,753	0	0	54,292	0	92,613	-132,152
Total		579,787	0	0	1,437,861	0	3,639,690	-4,497,764

4.3 Leakage

As per the methodology, leakage from a switch to non-renewable biomass use or fossil fuels is the possible source of leakage. In the project, organic manure is used, and any shift occurs within the farm boundary. Hence the leakage, ex-ante is estimated as 0. The methodology further states that If the ABMS survey data show that 10% or fewer project households use non-renewable biomass from outside the project or fossil fuels to replace the biomass diverted to agricultural fields, then the leakage is considered insignificant and ignored. In the project as verified from the interviews with the farmers, there is no diversion of the biomass as the crop residues which were earlier burnt are recycled back to the soil to increase the organic content. This was verified from the survey data and from periodic interviews with the farmers related to such practices. This concluded that such wastes are not used for any energy purposes such as for cooking or heating purposes as the households had already other means of fuels such as LPG or charcoal or firewood, the usage of sugarcane and paddy wastes for cooking application is not practiced in the project region. These sugarcane wastes were burnt in the open fields in the baseline and the paddy wastes are used as fodder for the cattle both in the baseline and in the project activity. Further, to ensure that the leakage is considered in a conservative way, the avoidance of crop burning has not been considered for the claimed GHG emission reductions.

Therefore, as per the methodology, the ex-ante estimate of leakage is zero.

LHE t = 0.

4.4 Estimated Net GHG Emission Reductions and Removals

The estimation of net anthropogenic GHG removal by sink is made using equation 8 of the methodology

$$\Delta R_t = BE_t - PE_t - LHE_t$$

Where

ΔR_t Estimate of net anthropogenic GHG emissions and removals in year t, t CO₂e

PE_t Estimate of actual net project GHG emissions and removals in year t, t CO₂e

BE_t Baseline emissions and removals in year t, t CO₂e

LHE_t the leakage from a switch to non-renewable biomass or fossil fuel in place of the biomass used for cooking /heating diverted to agricultural system in year t, t CO₂ e

Table 33: Estimated net GHG emission reductions for the project crediting period

Year	Estimated baseline emissions or removals	Estimated project emissions or removals	Estimated leakage emissions	Estimated net GHG emission reductions or removals
	(tCO ₂ e)	(tCO ₂ e)	(tCO ₂ e)	(tCO ₂ e)
1st oct 2017	4,918	-23,358	0	28,276
2018	19,670	-94,345	0	114,015
2019	19,670	-98,003	0	117,673
2020	19,670	-105,162	0	124,832
2021	19,670	-116,327	0	135,997
2022	19,670	-131,896	0	151,567
2023	21,856	-143,405	0	165,261
2024	21,856	-144,551	0	166,407
2025	21,856	-145,715	0	167,571
2026	21,856	-146,898	0	168,754
2027	21,856	-148,100	0	169,956
2028	21,856	-149,321	0	171,177
2029	21,856	-150,561	0	172,417
2030	21,856	-151,820	0	173,676
2031	21,856	-153,098	0	174,954
2032	21,856	-154,396	0	176,252
2033	21,856	-155,712	0	177,568
2034	21,856	-157,048	0	178,904
2035	21,856	-158,403	0	180,259

2036	21,856	-159,778	0	181,634
2037	21,856	-161,172	0	183,028
2038	21,856	-162,586	0	184,442
2039	21,856	-164,019	0	185,875
2040	21,856	-165,472	0	187,329
2041	21,856	-166,945	0	188,802
2042	21,856	-168,438	0	190,294
2043	21,856	-169,951	0	191,807
2044	21,856	-171,484	0	193,340
2045	21,856	-173,037	0	194,893
2046	21,856	-174,610	0	196,466
30 th Sept 2047	16,392	-132,152	0	148,544
Total	644,208	-4,497,764	0	5,141,971

5 MONITORING

5.1 Data and Parameters Available at Validation

Data collected and archived for baseline GHG emissions and removals:

Data / Parameter	$BSN_{t=0}$
Data unit	kg/ha
Description	Synthetic fertilizer use in the baseline period for the project area
Source of data	Baseline data compiled by VGS monitoring team from interview with farmers and farmer associations. The total usage of chemical fertilizer in each farm was quantified and the average was calculated based on crop area of 51,764 hectares.
Value applied:	347 kg/ hectare ²⁸
Justification of choice of data or description of measurement methods and procedures applied	It is based on field data recorded from interviews with farmer and farmer associations
Purpose of Data	Baseline GHG emissions and removals
Comments	It is recorded annually for each farm and reported before project start date

²⁸ <https://raitamitra.karnataka.gov.in/info-4/Agriculture+Statistics/en>

Data / Parameter	$Crop_{i,t=0}$
Data unit	kg d.m./ha
Description	Harvested seasonal dry matter yield for crop I in the baseline period for the project area
Source of data	Farm diary – data compiled by VGS monitoring team
Value applied:	116,535t/ha/year
Justification of choice of data or description of measurement methods and procedures applied	It is based on field data recorded from interviews with farmer and farmer associations
Purpose of Data	Baseline GHG emissions and removals
Comments	It is recorded annually for each farm and reported before project start date

Data / Parameter	$Area_{i,t=0}$
Data unit	ha
Description	total annual area harvested of crop
Source of data	Farm diary – data compiled by VGS monitoring team
Value applied:	Data for planted area as available at the start date of the project was applied 51,764 hectares.
Justification of choice of data or description of measurement methods and procedures applied	It is based on field data recorded from interviews with farmer and farmer associations
Purpose of Data	Baseline GHG emissions and removals
Comments	It is recorded annually for each farm and reported before project start date

Data / Parameter	$Areaburnt_{i,t=0}$
Data unit	ha
Description	annual area of crop <i>i</i> or N-fixing trees <i>i</i> burnt
Source of data	Not applicable as not monitored
Value applied:	Not applicable
Justification of choice of data or description of measurement methods and procedures applied	Not applicable

Purpose of Data	Baseline GHG emissions and removals
Comments	

Data / Parameter	$MB_{C,t=0}$
Data unit	t d.m.
Description	Not applicable as not monitored
Source of data	Not applicable
Value applied:	Not applicable
Justification of choice of data or description of measurement methods and procedures applied	Not applicable
Purpose of Data	Baseline GHG emissions and removals
Comments	

Data / Parameter	C_F
Data unit	unitless
Description	Combustion factors that depend on vegetation type
Source of data	Not applicable
Value applied:	Not applicable
Justification of choice of data or description of measurement methods and procedures applied	Not applicable
Purpose of Data	Baseline GHG emissions and removals
Comments	-

Data / Parameter	$FC_{j,t}$			
Data unit	Liters			
Description	Fossil fuel consumed in vehicle or equipment recorded by vehicle and fuel type during baseline period			
Source of data	Baseline Survey of the farm equipment by VGS			
Value applied:	Year	litres/year	Crop area	litres/ha
	2016	486,146	51,764	9.39

Justification of choice of data or description of measurement methods and procedures applied	Baseline survey conducted by VGS based on interview with farmers.
Purpose of Data	Baseline GHG emissions and removals
Comments	It is reported prior to start date of the project

Data / Parameter	$BA_{c, m_c, t=0}$
Data unit	ha
Description	Baseline areas in cropland with management practice, mC
Source of data	Survey of farmers and farmer associations
Value applied:	Not applicable as there are no baseline areas with management practice (SALM practices) prior to start date
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Baseline GHG emissions and removals
Comments	Reported prior to project start dates

Data / Parameter	$SOC_{c, m_c, t=0}$		
Data unit	tC/ha		
Description	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland in baseline, mC		
Source of data	Calculated based on the soil testing conducted on the farms during the baseline period for each IPCC climatic zone.		
Value applied:	IPCC Zone	Average SOC (t/C) from lab analysis	
	Tropical dry	25.02	
	Tropical moist	25.56	
	Tropical wet	20.14	
Justification of choice of data or description of measurement methods and procedures applied	The laboratory soil testing is recommended practice.		
Purpose of Data	Baseline GHG emissions and removals		
Comments	It is recorded prior to the project start date.		

Data / Parameter	$BP_{c,m_c,t=0}$
Data unit	t/ha
Description	Baseline production in cropland per season with management practice from within the project, mC
Source of data	baseline survey by VGS monitoring team based on data from farmer and farmer associations. The crop yield was recorded across all IPCC climatic zones in the project area of 51,764 hectares.
Value applied:	1,449,755 (tonnes)
Justification of choice of data or description of measurement methods and procedures applied	Baseline survey conducted by VGS
Purpose of Data	Baseline GHG emissions and removals
Comments	It is recorded prior to the project start date.

Data / Parameter	$BRC_{mc,t=0}$
Data unit	t/ha /month
Description	Baseline fraction of production returned as residues per month (calculated from $BPC_{mC,t=0}$) in cropland with management practice, mC
Source of data	Baselie survey compiled by VGS monitoring team based on data from farmer and farmer associations. The crop yield was recorded across all IPCC climatic zones in the project area of 51,764 hectares.
Value applied:	For details refer to monitoring sheet- ABMS_Monitoring_Data_Fertilizer_Version_5_VERRA.xlsx (Monitoring data - 2017, AA & AB column)
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Baseline GHG emissions and removals
Comments	It is recorded seasonally according to crops and reported annually

Data / Parameter	\overline{Temp}_m
Data unit	°C
Description	Average temperature per month
Source of data	Annual Report (media_to_upload1691669377.pdf (karnataka.gov.in))

Value applied:	<p>For each modeled year the previous 5 years monthly data values are compiled and used. Refer to calculation sheet</p> <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Tropical dry</th> </tr> <tr> <th style="text-align: center;">Months</th> <th style="text-align: center;">2012-2016</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">Jan</td><td style="text-align: center;">23.15</td></tr> <tr><td style="text-align: center;">Feb</td><td style="text-align: center;">25.27</td></tr> <tr><td style="text-align: center;">Mar</td><td style="text-align: center;">28.44</td></tr> <tr><td style="text-align: center;">Apr</td><td style="text-align: center;">29.82</td></tr> <tr><td style="text-align: center;">May</td><td style="text-align: center;">29.78</td></tr> <tr><td style="text-align: center;">Jun</td><td style="text-align: center;">27.09</td></tr> <tr><td style="text-align: center;">Jul</td><td style="text-align: center;">25.61</td></tr> <tr><td style="text-align: center;">Aug</td><td style="text-align: center;">25.54</td></tr> <tr><td style="text-align: center;">Sep</td><td style="text-align: center;">25.96</td></tr> <tr><td style="text-align: center;">Oct</td><td style="text-align: center;">25.97</td></tr> <tr><td style="text-align: center;">Nov</td><td style="text-align: center;">24.07</td></tr> <tr><td style="text-align: center;">Dec</td><td style="text-align: center;">23.14</td></tr> </tbody> </table> <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Tropical moist</th> </tr> <tr> <th style="text-align: center;">Months</th> <th style="text-align: center;">2012-2016</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">Jan</td><td style="text-align: center;">23.62</td></tr> <tr><td style="text-align: center;">Feb</td><td style="text-align: center;">24.99</td></tr> <tr><td style="text-align: center;">Mar</td><td style="text-align: center;">27.08</td></tr> <tr><td style="text-align: center;">Apr</td><td style="text-align: center;">28.27</td></tr> <tr><td style="text-align: center;">May</td><td style="text-align: center;">28.00</td></tr> <tr><td style="text-align: center;">Jun</td><td style="text-align: center;">25.43</td></tr> <tr><td style="text-align: center;">Jul</td><td style="text-align: center;">24.33</td></tr> <tr><td style="text-align: center;">Aug</td><td style="text-align: center;">24.42</td></tr> <tr><td style="text-align: center;">Sep</td><td style="text-align: center;">24.87</td></tr> <tr><td style="text-align: center;">Oct</td><td style="text-align: center;">25.63</td></tr> <tr><td style="text-align: center;">Nov</td><td style="text-align: center;">24.62</td></tr> <tr><td style="text-align: center;">Dec</td><td style="text-align: center;">23.89</td></tr> </tbody> </table> <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Tropical wet</th> </tr> <tr> <th style="text-align: center;">Months</th> <th style="text-align: center;">2012-2016</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">Jan</td><td style="text-align: center;">27.43</td></tr> <tr><td style="text-align: center;">Feb</td><td style="text-align: center;">28.56</td></tr> <tr><td style="text-align: center;">Mar</td><td style="text-align: center;">29.97</td></tr> <tr><td style="text-align: center;">Apr</td><td style="text-align: center;">30.57</td></tr> <tr><td style="text-align: center;">May</td><td style="text-align: center;">30.21</td></tr> <tr><td style="text-align: center;">Jun</td><td style="text-align: center;">27.52</td></tr> <tr><td style="text-align: center;">Jul</td><td style="text-align: center;">26.55</td></tr> <tr><td style="text-align: center;">Aug</td><td style="text-align: center;">26.66</td></tr> <tr><td style="text-align: center;">Sep</td><td style="text-align: center;">27.43</td></tr> </tbody> </table>	Tropical dry		Months	2012-2016	Jan	23.15	Feb	25.27	Mar	28.44	Apr	29.82	May	29.78	Jun	27.09	Jul	25.61	Aug	25.54	Sep	25.96	Oct	25.97	Nov	24.07	Dec	23.14	Tropical moist		Months	2012-2016	Jan	23.62	Feb	24.99	Mar	27.08	Apr	28.27	May	28.00	Jun	25.43	Jul	24.33	Aug	24.42	Sep	24.87	Oct	25.63	Nov	24.62	Dec	23.89	Tropical wet		Months	2012-2016	Jan	27.43	Feb	28.56	Mar	29.97	Apr	30.57	May	30.21	Jun	27.52	Jul	26.55	Aug	26.66	Sep	27.43
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May	30.21																																																																														
Jun	27.52																																																																														
Jul	26.55																																																																														
Aug	26.66																																																																														
Sep	27.43																																																																														

		Oct	28.33	
		Nov	28.31	
		Dec	27.88	
Justification of choice of data or description of measurement methods and procedures applied	N/A			
Purpose of Data	Baseline GHG emissions and removals			
Comments	It is recorded and reported annually			

Data / Parameter	\overline{Prec}_m																																								
Data unit	mm																																								
Description	Average precipitation per month																																								
Source of data	Annual Reports - Directorate of Economics and Statistics-Karnataka (Reports - Directorate of Economics and Statistics (karnataka.gov.in))																																								
Value applied:	<p>For each modeled year the previous 5 years monthly data values are compiled and used. Refer to calculation sheet</p> <table border="1"> <thead> <tr> <th colspan="2">Tropical dry</th> </tr> <tr> <th>Months</th> <th>2012-2016</th> </tr> </thead> <tbody> <tr><td>Jan</td><td>0.86</td></tr> <tr><td>Feb</td><td>2.44</td></tr> <tr><td>Mar</td><td>11.47</td></tr> <tr><td>Apr</td><td>44.73</td></tr> <tr><td>May</td><td>70.11</td></tr> <tr><td>Jun</td><td>95.00</td></tr> <tr><td>Jul</td><td>133.87</td></tr> <tr><td>Aug</td><td>110.15</td></tr> <tr><td>Sep</td><td>121.11</td></tr> <tr><td>Oct</td><td>96.12</td></tr> <tr><td>Nov</td><td>42.82</td></tr> <tr><td>Dec</td><td>7.09</td></tr> </tbody> </table> <table border="1"> <thead> <tr> <th colspan="2">Tropical moist</th> </tr> <tr> <th>Months</th> <th>2012-2016</th> </tr> </thead> <tbody> <tr><td>Jan</td><td>0.55</td></tr> <tr><td>Feb</td><td>4.13</td></tr> <tr><td>Mar</td><td>13.66</td></tr> <tr><td>Apr</td><td>46.37</td></tr> </tbody> </table>	Tropical dry		Months	2012-2016	Jan	0.86	Feb	2.44	Mar	11.47	Apr	44.73	May	70.11	Jun	95.00	Jul	133.87	Aug	110.15	Sep	121.11	Oct	96.12	Nov	42.82	Dec	7.09	Tropical moist		Months	2012-2016	Jan	0.55	Feb	4.13	Mar	13.66	Apr	46.37
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	<table border="1"> <tr><td>May</td><td>214.16</td></tr> <tr><td>Jun</td><td>246.77</td></tr> <tr><td>Jul</td><td>387.27</td></tr> <tr><td>Aug</td><td>246.97</td></tr> <tr><td>Sep</td><td>151.98</td></tr> <tr><td>Oct</td><td>96.01</td></tr> <tr><td>Nov</td><td>65.56</td></tr> <tr><td>Dec</td><td>15.25</td></tr> </table>	May	214.16	Jun	246.77	Jul	387.27	Aug	246.97	Sep	151.98	Oct	96.01	Nov	65.56	Dec	15.25												
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Justification of choice of data or description of measurement methods and procedures applied	N/A																												
Purpose of Data	Baseline GHG emissions and removals																												
Comments	-																												

Data / Parameter	\overline{Evap}_m														
Data unit	mm/month														
Description	Average evapotranspiration per month														
Source of data	USGS Monthly Evapotranspiration data (https://earlywarning.usgs.gov/fews/product/460)														
Value applied:	For each modeled year the previous 5 years Monthly data values are compiled and used <table border="1"> <thead> <tr><th colspan="2">Tropical dry</th></tr> <tr><th>Months</th><th>2012-2016</th></tr> </thead> <tbody> <tr><td>Jan</td><td>42.20</td></tr> <tr><td>Feb</td><td>45.58</td></tr> <tr><td>Mar</td><td>57.56</td></tr> <tr><td>Apr</td><td>56.13</td></tr> <tr><td>May</td><td>61.69</td></tr> </tbody> </table>	Tropical dry		Months	2012-2016	Jan	42.20	Feb	45.58	Mar	57.56	Apr	56.13	May	61.69
Tropical dry															
Months	2012-2016														
Jan	42.20														
Feb	45.58														
Mar	57.56														
Apr	56.13														
May	61.69														

	Jun	47.95
	Jul	41.19
	Aug	42.79
	Sep	40.61
	Oct	42.62
	Nov	37.82
	Dec	38.47
	Tropical moist	
	Months	2012-2016
	Jan	42.32
	Feb	45.04
	Mar	56.46
	Apr	53.50
	May	56.04
	Jun	41.57
	Jul	35.64
	Aug	38.55
	Sep	38.12
	Oct	41.37
	Nov	37.70
	Dec	39.11
	Tropical wet	
	Months	2012-2016
	Jan	41.98
	Feb	43.99
	Mar	54.58
	Apr	51.75
	May	53.30
	Jun	37.42
	Jul	30.96
	Aug	34.79
	Sep	35.69
	Oct	40.03
Nov	37.29	
Dec	38.94	
Justification of choice of data or description of measurement methods and procedures applied	N/A	
Purpose of Data	Baseline GHG emissions and removals	
Comments	-	

Data and parameters specific to the CDM tool “Estimation of carbon stocks and change in carbonstocks of trees and shrubs in A/R CDM project activities”:

Data / Parameter	R_j
Data unit	unitless
Description	Root-shoot ratio for tree species j
Source of data	Based on scientific studies of common native species in India.
Value applied:	0.30
Justification of choice of data or description of measurement methods and procedures applied	Based on scientific studies of common native species in India. P. Pawar et.al. Biomass Production and Carbon Sequestration Potential of Different Agroforestry Systems in India: A Critical Review Forests 2022, 13(8), 1274
Purpose of Data	To estimate the Below Ground biomass
Comments	NA

Data / Parameter	$A_{p,i}$
Data unit	ha
Description	Area under agroforestry tree planting
Source of data	Data based on the Number of trees planted in each farm and calculated based on tree density considering a spacing of 3m between each tree.
Value applied:	The eligible Agroforestry tree planting area of 5,752 hectares for this monitoring period.
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Baseline GHG emissions and removals
Comments	NA

Data / Parameter	DBH
Data unit	cm
Description	Diameter at breast height of agroforestry trees (long living trees)

Source of data	Refer calculation sheet based on CDM tool
Value applied:	To refer ABMS monitoring sheet for A/R activities
Justification of choice of data or description of measurement methods and procedures applied	Monitored using standard techniques as per Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities version 2.0. A measurement tape is used to estimate the DBH. For the inventory, all trees with DBH of 10 cm and above were considered as eligible.
Purpose of Data	Baseline GHG emissions and removals
Comments	In each farm, the DBH of all eligible trees were measured. During the process if noticed that the DBH is not representative of the tree's diameter due to an irregular growth, a second measurement was taken slightly above the growth and the point of measurement was used as opposed to the DBH. If the tree bifurcated below the point of measurement, it was measured as two separate trees. For this monitoring period, 5-year-old planted trees were considered eligible.

Data / Parameter	$f (DBH)$
Data unit	t d.m.
Description	Above- ground biomass (AGB) was calculated using the Allometric equation.
Source of data	<p>Biomass volume is calculated using the allometric equation 3.2.4²⁹ for tropical moist biome based on Browns et al. (1989)³⁰</p> $Y = \exp\{-2.134+2.530*\ln(D)\}$ <p>Where,</p> <p>Y biomass per tree in kg</p> <p>D dbh in cm</p> <p>Biomass volume is calculated using the allometric equation 3.2.1 for tropical dry biome based on Browns et al. (1989)¹⁴</p> $Y = \exp\{-1.996+2.32*\ln(D)\}$

²⁹ 3. METHODS FOR ESTIMATING BIOMASS DENSITY FROM EXISTING DATA (fao.org)

	Where, Y biomass per tree in kg D dbh in cm Biomass volume is calculated using the allometric equation 3.2.5 for tropical wet biome based on Browns et al. (1989)14 $Y = 21.297 - 6.953(D) + 0.740(D^2)$ Where, Y biomass per tree in kg D dbh in cm
Value applied:	To refer ABMS monitoring sheet for A/R activities
Justification of choice of data or description of measurement methods and procedures applied	Monitored using standard techniques as per Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities version 4.2
Purpose of Data	Baseline GHG emissions and removals
Comments	Volume was derived from the DBH and height measurements which were then multiplied with the Wood density and Biomass expansion factor to calculate the biomass which was then converted to tCO ₂ e / hectare using standard conversion factors.

5.2 Data and Parameters Monitored

Data to be collected and archived for project GHG emissions and removals as applicable for the first monitoring period

Data / Parameter	PSN_t		
Data unit	kg/year		
Description	Annual Synthetic fertilizer use		
Source of data	Farm Diary – compiled by VGS monitoring team		
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff		
Frequency of monitoring/recording	Annually		
Value applied:	Year	Synthetic fertilizer usage (Ton)	organic fertilizer usage (Ton)
	1st Oct 2017	5,569	1,367

	2018	15,594	2,015
	2019	12,217	2,403
	2020	10,025	2,670
	2021	6,683	3,205
	30th Sep 2022	10,935	5,826
Monitoring equipment	Farm Diary		
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.		
Purpose of data	Project GHG emissions and removals		
Calculation method	Reported by farmers through farm diary data		
Comments	NA		

Data / Parameter	$PA_{C,t}$
Data unit	ha/year
Description	Areas in cropland under project activity
Source of data	Farm Diary – compiled by VGS monitoring team
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff team based on information from the farmer and farmer associations. The area under the project activity is cross checked with database from the farmer associations. This is then converted to the KML file demarcating the boundary and point location is also provided for the farm.
Frequency of monitoring/recording	Annually
Value applied:	Refer to ABMS monitoring sheet
Monitoring equipment	Farm Diary
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	PF_t
Data unit	USD/kg
Description	the price of inorganic fertilizer

Source of data	Based on published reports and information from farmer associations. Fertilizer statistics handbook 2021-2022, published by Fertilizer association of India
Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	Annual
Value applied:	Urea - \$0.086 USD/kg
Monitoring equipment	NA
QA/QC procedures to be applied	NA
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	$Crop_{i,t}$															
Data unit	kg d.m./ha/year															
Description	Harvested annual dry matter yield for crop i															
Source of data	Farm Diary															
Description of measurement methods and procedures to be applied	Farmer self-assessment and cross-check by VGS field staff															
Frequency of monitoring/recording	Annually															
Value applied:	<table border="1"> <thead> <tr> <th>Year</th> <th>Harvested annual Dry Matter (Tonne/ha/year)</th> </tr> </thead> <tbody> <tr> <td>1st Oct 2017</td> <td>38,845</td> </tr> <tr> <td>2018</td> <td>633,951</td> </tr> <tr> <td>2019</td> <td>645,231</td> </tr> <tr> <td>2020</td> <td>649,489</td> </tr> <tr> <td>2021</td> <td>658,812</td> </tr> <tr> <td>30th Sep 2022</td> <td>506,462</td> </tr> </tbody> </table>	Year	Harvested annual Dry Matter (Tonne/ha/year)	1st Oct 2017	38,845	2018	633,951	2019	645,231	2020	649,489	2021	658,812	30th Sep 2022	506,462	
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30th Sep 2022	506,462															
Monitoring equipment	Farm diary															
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.															
Purpose of data	Project GHG emissions and removals															
Calculation method	Farmers report cropland in hectares.															
Comments	NA															

Data / Parameter	$Area_{i,t}$
Data unit	ha/year
Description	Total seasonal area harvested of crop I
Source of data	Farm Diary
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff. team based on information from the farmer and farmer associations. The area under the project activity is cross checked with database from the farmer associations. This is then converted to the KML file demarcating the boundary and point location is also provided for the farm.
Frequency of monitoring/recording	Annually
Value applied:	Refer to ABMS Monitoring sheets
Monitoring equipment	Farm diary - Full census ABMS monitoring approach
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	$Areaburnt_{i,t}$
Data unit	Ha/ year
Description	Seasonal area of crop I
Source of data	Not applicable as not monitored
Description of measurement methods and procedures to be applied	Not applicable
Frequency of monitoring/recording	-
Value applied:	-
Monitoring equipment	-
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.
Purpose of data	Project GHG emissions and removals
Calculation method	Farm diary

Comments	NA
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Data / Parameter	$MB_{C,t}$
Data unit	t d.m./year
Description	Mass of crop residues burnt
Source of data	Not applicable
Description of measurement methods and procedures to be applied	Not applicable
Frequency of monitoring/recording	Not applicable
Value applied:	Not applicable
Monitoring equipment	--
QA/QC procedures to be applied	--
Purpose of data	Project GHG emissions and removals
Calculation method	-
Comments	-

Data / Parameter	C_F
Data unit	unitless
Description	Combustion factors that depend on vegetation type
Source of data	IPCC value according to guidance of the applied Methodology VM0017
Description of measurement methods and procedures to be applied	Not applicable
Frequency of monitoring/recording	Not applicable
Value applied:	Not applicable
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Project GHG emissions and removals
Calculation method	Not applicable
Comments	Not applicable

Data / Parameter	FC _{j,t}			
Data unit	Liters			
Description	Fossil fuel consumed in vehicle or equipment recorded by vehicle and fuel type			
Source of data	Monitoring by VGS staff			
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff			
Frequency of monitoring/recording	Annually			
Value applied:	Year	litres/year	Crop area	litres /ha
	1st OCT 2017	60,516	51,764	1.17
	2018	108,929	51,764	2.10
	2019	54,465	51,764	1.05
	2020	27,232	51,764	0.53
	2021	10,212	51,764	0.20
	30th Sep 2022	13,344	51,764	0.26
Monitoring equipment	Monitoring by VGS staff - Full census ABMS monitoring approach			
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.			
Purpose of data	Project GHG emissions and removals			
Calculation method	Farmers report on the use of machinery on cropland. Only applied if significant, increase of machinery used by farmers monitored is observed.			
Comments	NA			

Data / Parameter	PA_{C,m_c} , t
Data unit	Ha/year
Description	Project areas in cropland with management practice, m_c
Source of data	Farm diary
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff
Frequency of monitoring/recording	Annually

Value applied:	Refer ABMS monitoring sheet
Monitoring equipment	Full census ABMS monitoring approach - Farm diary and cross check using GIS maps
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.
Purpose of data	Project GHG emissions and removals
Calculation method	Farmers report all agricultural practices on their farmland as well as the area where these practices are applied.
Comments	NA

Data / Parameter	$SOC_{C,m_c,t}$										
Data unit	tC/ha										
Description	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland with management practice, m_c										
Source of data	RothC model										
Description of measurement methods and procedures to be applied	Through quantitative analysis, RothC model calculations were conducted by projecting the model from 2018 onwards until 2022 to arrive at the average SOC. The detailed SOP is provided in Appendix 1.										
Frequency of monitoring/recording	Modeled for baseline and project scenario for each IPCC zone within a monitoring period. The average SOC across all IPCC zones for 1 st October 2017-30 th September 2022 is summarized below.										
Value applied:		<table border="1"> <thead> <tr> <th>IPCC Zone</th> <th>Average SOC t/C (RothC modelled)</th> </tr> </thead> <tbody> <tr> <td>Tropical dry</td> <td>25.43</td> </tr> <tr> <td>Tropical moist</td> <td>24.55</td> </tr> <tr> <td>Tropical wet</td> <td>19.43</td> </tr> </tbody> </table>	IPCC Zone	Average SOC t/C (RothC modelled)	Tropical dry	25.43	Tropical moist	24.55	Tropical wet	19.43	
IPCC Zone	Average SOC t/C (RothC modelled)										
Tropical dry	25.43										
Tropical moist	24.55										
Tropical wet	19.43										
Monitoring equipment	RothC model										
QA/QC procedures to be applied	RothC model has been for each IPCC climatic zone.										
Purpose of data	Project GHG emissions and removals										
Calculation method	Modeled with RothC model Modelled with RothC using input values for: Baseline $BR_{C,m_c,t=0}, BA_{C,m_c,t=0}, BM_{C,m_c,t=0}$ Project: $PR_{C,m_c,t}, PA_{C,m_c,t}, PM_{C,m_c,t}, \overline{Temp}_m, \overline{Prec}_m,$										

	$\overline{Evap}_m, PT_{C,t}$
Comments	NA

Data / Parameter	$PP_{C,mc}, t$														
Data unit	t/ha/year														
Description	Production in cropland per season with management practice from within the project, mC														
Source of data	Farm diary														
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff														
Frequency of monitoring/recording	Annually														
Value applied:	Refer ABMS monitoring sheet. <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Year</th> <th>Crop Production (tonnes)</th> </tr> </thead> <tbody> <tr> <td>1st Oct 2017</td> <td>483,252</td> </tr> <tr> <td>2018</td> <td>1,971,666</td> </tr> <tr> <td>2019</td> <td>2,011,100</td> </tr> <tr> <td>2020</td> <td>2,019,992</td> </tr> <tr> <td>2021</td> <td>2,051,503</td> </tr> <tr> <td>30th Sep 2022</td> <td>1,586,458</td> </tr> </tbody> </table>	Year	Crop Production (tonnes)	1st Oct 2017	483,252	2018	1,971,666	2019	2,011,100	2020	2,019,992	2021	2,051,503	30th Sep 2022	1,586,458
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30th Sep 2022	1,586,458														
Monitoring equipment	Farm diary - Full census ABMS monitoring approach														
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.														
Purpose of data	Project GHG emissions and removals														
Calculation method	NA														
Comments	NA														

Data / Parameter	$PR_{C,mc}, t$
Data unit	tC/ha/season

Description	Project fraction of production returned as residues per season in cropland with management practice, mC (calculated from $PPC_{C,mC,t}$)																																																															
Source of data	Farm diary																																																															
Description of measurement methods and procedures to be applied	Farmer self-assessment and cross check by VGS field staff																																																															
Frequency of monitoring/recording	Annually (seasons in a year are added)																																																															
Value applied:	<table border="1"> <thead> <tr> <th colspan="7">crop residue (t/ha/season)</th> </tr> <tr> <th>IPCC Zone</th> <th colspan="2">Tropical dry</th> <th colspan="2">Tropical moist</th> <th colspan="2">Tropical wet</th> </tr> <tr> <th>Year</th> <th>Rabi crop</th> <th>Khar if crop</th> <th>Rabi crop</th> <th>Khari f crop</th> <th>Rabi crop</th> <th>Khar if crop</th> </tr> </thead> <tbody> <tr> <td>1st Oct 2017</td> <td>0.68</td> <td>2.31</td> <td>0.67</td> <td>2.25</td> <td>0.53</td> <td>2.02</td> </tr> <tr> <td>2018</td> <td>0.76</td> <td>2.6</td> <td>0.75</td> <td>2.53</td> <td>0.59</td> <td>2.27</td> </tr> <tr> <td>2019</td> <td>0.8</td> <td>2.75</td> <td>0.78</td> <td>2.69</td> <td>0.62</td> <td>2.41</td> </tr> <tr> <td>2020</td> <td>0.79</td> <td>2.9</td> <td>0.77</td> <td>2.83</td> <td>0.61</td> <td>2.54</td> </tr> <tr> <td>2021</td> <td>0.89</td> <td>3.02</td> <td>0.87</td> <td>2.94</td> <td>0.69</td> <td>2.64</td> </tr> <tr> <td>30th Sep 2022</td> <td>0.92</td> <td>3.13</td> <td>0.9</td> <td>3.05</td> <td>0.71</td> <td>2.73</td> </tr> </tbody> </table>	crop residue (t/ha/season)							IPCC Zone	Tropical dry		Tropical moist		Tropical wet		Year	Rabi crop	Khar if crop	Rabi crop	Khari f crop	Rabi crop	Khar if crop	1st Oct 2017	0.68	2.31	0.67	2.25	0.53	2.02	2018	0.76	2.6	0.75	2.53	0.59	2.27	2019	0.8	2.75	0.78	2.69	0.62	2.41	2020	0.79	2.9	0.77	2.83	0.61	2.54	2021	0.89	3.02	0.87	2.94	0.69	2.64	30 th Sep 2022	0.92	3.13	0.9	3.05	0.71	2.73
crop residue (t/ha/season)																																																																
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Monitoring equipment	Farm Diary - Full census ABMS monitoring approach																																																															
QA/QC procedures to be applied	The values reported by the farmers are crosschecked by the field coordinators through internal inspection at regular intervals.																																																															
Purpose of data	Project GHG emissions and removals																																																															
Calculation method	Calculated from $PPC_{C,m,t}$ and $PAC_{C,m,t}$ for residue management																																																															
Comments	NA																																																															

Data / Parameter	$PM_{C,mC,t}$
Data unit	t/ha/year
Description	Project farmyard manure input in cropland per season with management practice, mC
Source of data	Farmer Diary – compiled by VGS monitoring team and cross checked.

Description of measurement methods and procedures to be applied	Farmer self-assessment and cross-check by VGS field staff		
Frequency of monitoring/recording	Annually		
Value applied:		Year	FYM (tC/ha/yr)
		1st Oct 2017	4,636
		2018	18,705
		2019	24,939
		2020	31,174
		2021	37,409
		30th Sep 2022	37,409
Monitoring equipment	Farmer diary- Full census ABMS monitoring approach		
QA/QC procedures to be applied	The farmyard manure inputs reported by the farmers are crosschecked by the field coordinators during periodic inspections.		
Purpose of data	Project GHG emissions and removals		
Calculation method	NA		
Comments	NA		

Data / Parameter	\overline{Temp}_m																																																
Data unit	°C																																																
Description	Average temperature per month																																																
Source of data	Annual Report- Government of Karnataka																																																
Description of measurement methods and procedures to be applied	<p>Incorporated year on year weather data into the RothC model to calculate $SOCC_{mc,t}$</p> <table border="1" style="margin-left: 40px;"> <thead> <tr> <th colspan="6">Tropical dry</th> </tr> <tr> <th>Months</th> <th>2018</th> <th>2019</th> <th>2020</th> <th>2021</th> <th>2022</th> </tr> </thead> <tbody> <tr> <td>Jan</td> <td>22.83</td> <td>22.20</td> <td>24.00</td> <td>23.74</td> <td>24.91</td> </tr> <tr> <td>Feb</td> <td>24.65</td> <td>25.67</td> <td>25.20</td> <td>25.73</td> <td>24.31</td> </tr> <tr> <td>Mar</td> <td>27.95</td> <td>28.77</td> <td>27.33</td> <td>25.61</td> <td>24.52</td> </tr> <tr> <td>Apr</td> <td>30.05</td> <td>30.80</td> <td>29.89</td> <td>24.99</td> <td>24.86</td> </tr> <tr> <td>May</td> <td>29.94</td> <td>29.59</td> <td>30.56</td> <td>24.36</td> <td>24.74</td> </tr> <tr> <td>Jun</td> <td>26.84</td> <td>28.34</td> <td>27.19</td> <td>25.69</td> <td>25.23</td> </tr> </tbody> </table>	Tropical dry						Months	2018	2019	2020	2021	2022	Jan	22.83	22.20	24.00	23.74	24.91	Feb	24.65	25.67	25.20	25.73	24.31	Mar	27.95	28.77	27.33	25.61	24.52	Apr	30.05	30.80	29.89	24.99	24.86	May	29.94	29.59	30.56	24.36	24.74	Jun	26.84	28.34	27.19	25.69	25.23
Tropical dry																																																	
Months	2018	2019	2020	2021	2022																																												
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	Jul	25.52	26.18	25.97	25.15	26.11	
	Aug	25.04	25.45	25.20	26.20	24.85	
	Sep	26.25	25.71	25.71	24.29	25.22	
	Oct	26.05	25.68	25.49	25.07	24.81	
	Nov	24.87	24.78	24.12	25.03	25.04	
	Dec	23.49	23.46	22.79	25.29	25.64	
	Tropical moist						
	Months	2018	2019	2020	2021	2022	
	Jan	23.60	22.97	24.45	28.60	24.35	
	Feb	24.87	25.29	25.22	26.80	25.25	
	Mar	27.25	27.24	27.13	23.53	26.38	
	Apr	28.69	29.19	28.71	26.93	25.90	
	May	27.74	29.11	28.75	24.10	23.28	
	Jun	25.09	26.70	25.60	25.45	25.85	
	Jul	24.23	24.76	25.07	26.70	26.45	
Aug	23.93	24.38	24.22	26.03	24.18		
Sep	25.43	24.90	25.01	27.10	23.53		
Oct	26.22	25.79	25.20	23.45	21.05		
Nov	25.34	25.79	25.45	25.10	22.93		
Dec	24.52	25.12	24.48	24.05	25.23		
Tropical wet							
Months	2018	2019	2020	2021	2022		
Jan	26.53	25.68	26.98	22.18	26.43		
Feb	27.45	27.78	27.78	22.90	24.23		
Mar	29.00	28.78	28.90	26.23	25.10		
Apr	29.98	30.45	30.30	26.58	26.40		
May	28.83	30.68	29.93	24.05	23.68		
Jun	26.50	28.48	27.00	24.83	25.90		
Jul	26.13	26.63	26.48	25.40	25.30		
Aug	25.55	26.33	26.13	25.05	23.80		
Sep	27.18	26.90	26.43	24.80	25.08		
Oct	28.20	27.53	26.63	24.55	27.45		
Nov	27.95	28.20	27.88	26.05	23.98		
Dec	27.08	27.60	27.48	24.93	25.88		
Frequency of monitoring/recording	monthly						
Value applied:	Refer SOC Calculation Sheet						
Monitoring equipment	Input for RothC models						

QA/QC procedures to be applied	Uncertainty analysis. Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of $SOCC,m_c^t$
Purpose of data	Project GHG emissions and removals
Calculation method	Collected from IMD
Comments	NA

Data / Parameter	\overline{Prec}_m																																																																																																																																																												
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	Nov	18.95	31.38	25.13	209.60	31.10
	Dec	8.38	22.98	15.58	26.75	32.23
	Tropical wet					
	Months	2018	2019	2020	2021	2022
	Jan	0.00	0.00	0.00	72.10	0.23
	Feb	0.55	0.70	0.55	16.23	0.48
	Mar	34.00	3.98	11.18	11.83	28.15
	Apr	48.40	33.18	64.03	91.63	79.88
	May	324.50	30.98	143.08	375.28	282.80
	Jun	1063.15	516.05	732.75	710.63	532.48
	Jul	1120.15	1059.03	887.35	982.25	1480.53
	Aug	1092.73	1378.20	1121.15	505.48	830.48
	Sep	105.45	634.75	769.55	471.93	363.35
	Oct	173.43	482.18	296.15	330.60	158.28
Nov	22.83	55.68	26.15	238.43	46.08	
Dec	9.95	21.03	12.33	27.60	24.43	
Frequency of monitoring/recording	monthly					
Value applied:	Refer SOC Calculation Sheet					
Monitoring equipment	Input for RothC models					
QA/QC procedures to be applied	Uncertainty analysis: Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of $SO_{C,m}^t$					
Purpose of data	Project GHG emissions and removals					
Calculation method	Collected from IMD					
Comments	NA					

Data / Parameter	\overline{Evap}_m																														
Data unit	mm/day																														
Description	Average evapotranspiration per month																														
Source of data	USGS - Monthly Evapotranspiration data (https://earlywarning.usgs.gov/fews/product/460)																														
Description of measurement methods and procedures to be applied	ET calculated using Operational Simplified Surface Energy Balance (SSEBop) model																														
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Tropical dry																															
Months	2018	2019	2020	2021	2022																										
Jan	37.31	40.06	40.52	39.74	38.89																										
Feb	41.58	42.51	45.61	43.26	43.58																										
Mar	50.80	59.09	55.85	57.08	54.76																										

	Apr	50.64	59.18	56.87	55.67	53.88
	May	50.82	63.31	60.30	57.97	54.56
	Jun	41.33	50.56	45.91	46.02	46.90
	Jul	38.52	40.73	36.70	39.38	34.94
	Aug	39.65	39.89	39.80	41.08	41.12
	Sep	40.68	36.27	35.97	40.46	37.71
	Oct	41.80	35.34	38.45	40.05	38.50
	Nov	36.73	35.42	37.91	35.91	35.96
	Dec	34.16	33.73	38.08	36.08	34.94
	Tropical moist					
Months	2018	2019	2020	2021	2022	
Jan	38.55	41.39	40.36	40.07	39.35	
Feb	42.43	42.80	45.22	43.15	43.16	
Mar	50.13	57.26	54.16	55.91	54.26	
Apr	48.00	55.53	54.09	53.42	50.31	
May	47.15	59.65	55.23	52.40	47.42	
Jun	35.97	46.27	41.76	41.55	42.21	
Jul	34.31	36.84	34.07	35.96	32.59	
Aug	35.39	36.04	37.07	38.41	38.09	
Sep	40.77	35.25	34.36	38.64	36.60	
Oct	40.79	34.37	37.12	38.83	37.90	
Nov	37.67	36.29	38.36	35.43	36.34	
Dec	34.42	35.32	38.81	36.55	35.84	
Tropical wet						
Months	2018	2019	2020	2021	2022	
Jan	39.79	42.39	40.33	39.98	39.95	
Feb	42.45	42.97	44.34	42.96	42.71	
Mar	49.01	55.96	52.85	54.02	52.69	
Apr	46.49	53.49	52.04	51.79	47.60	
May	45.10	57.93	52.23	49.71	44.08	
Jun	33.04	43.89	38.45	38.74	39.14	
Jul	30.31	32.48	31.54	32.94	30.92	
Aug	32.08	31.85	34.71	36.32	36.37	
Sep	41.65	33.84	32.74	36.90	35.97	
Oct	40.51	33.48	35.95	38.30	38.50	
Nov	38.27	37.42	39.64	35.41	36.96	
Dec	35.01	36.11	39.64	37.14	36.72	
Frequency of monitoring/recording	monthly					
Value applied:	Refer SOC Calculation Sheet					
Monitoring equipment	Input for RothC models					

QA/QC procedures to be applied	Uncertainty analysis. Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of $SOC_{C,m}^t$
Purpose of data	Project GHG emissions and removals
Calculation method	It is calculated from climate data and solar radiation
Comments	NA

Data / Parameter	D
Data unit	Years
Description	Transition period
Source of data	IPCC default period as proposed in the methodology VM0017
Description of measurement methods and procedures to be applied	n/a
Frequency of monitoring/recording	Assumed for baseline and project modeling. The Methodology proposes an IPCC default value of 20 years
Value applied:	20 years.
Monitoring equipment	Excel RothC models
QA/QC procedures to be applied	The RothC models are standardized and semi-automatic, this is to ensure that only input values for a specific monitoring period are entered.
Purpose of data	NA
Calculation method	Automatic calculation using the RothC models
Comments	NA

Data and parameters collected and archived for use with the CDM tool 'Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities' to calculate change in carbon stock within the project boundary:

Data / Parameter	<i>RJ</i>
Data unit	<i>unitless</i>
Description	<i>Root-shoot ratio for tree species j</i>

Source of data	<i>Based on scientific studies of common native species in India.</i>
Description of measurement methods and procedures to be applied	<i>Based and applied on measured DBH values</i>
Frequency of monitoring/recording	<i>Every verification cycle</i>
Value applied:	0.30
Monitoring equipment	<i>Farmer diary – Full census ABMS monitoring approach</i>
QA/QC procedure to be applied	<i>The DBH values reported in the farm diary are crosschecked by the field coordinators during periodic inspections</i>
Purpose of Data	<i>To estimate the Below Ground biomass of project trees</i>
Calculation method	<i>Based on scientific studies of common native species in India. Biomass Production and Carbon Sequestration Potential of Different Agroforestry Systems in India: A Critical Review 2022, 13(8), 1274 (source : https://doi.org/10.3390/f13081274)</i>
Comments	NA

Data / Parameter	DBH
Data unit	cm
Description	Diameter at breast height of agroforestry trees (long living trees)
Source of data	Field measurement
Description of measurement methods and procedures to be applied	<p>In each farm, the DBH of eligible trees were measured.</p> <p>During the process if noticed that the DBH is not representative of the tree's diameter due to an irregular growth, a second measurement was taken slightly above the growth and the point of measurement was used as opposed to the DBH. If the tree bifurcated below the point of measurement, it was measured as two separate trees.</p> <p>For this monitoring period, all eligible trees planted trees were considered for the biomass inventory conducted at the end of the 5-year monitoring period.</p>
Frequency of monitoring/recording	Annually
Value applied:	To refer ABMS monitoring sheet for A/R activities

Monitoring equipment	Full census- ABMS monitoring approach. Monitored using standard techniques as per Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities version 2.0. A measurement tape is used to estimate the DBH. For the inventory, all trees with DBH of 10 cm and above were considered.
QA/QC procedures to be applied	The QA/QC procedures involve re-measuring DBH values that may not accurately reflect the tree's diameter due to irregular growth. In such cases, a second measurement is taken just above the irregular growth, with the point of measurement being used instead of the DBH.
Purpose of Data	Baseline GHG emissions and removals
Calculation method	Field measurement
Comments	None

Data / Parameter	$f (DBH)$
Data unit	t d.m.
Description	Above- ground biomass (AGB) was calculated using the Allometric equation method.
Source of data	<p>Biomass volume is calculated using the allometric equation 3.2.4³¹ for tropical moist biome based on Browns et al. (1989)³²</p> $Y = \exp\{-2.134+2.530*\ln(D)\}$ <p>Where,</p> <p>Y biomass per tree in kg</p> <p>D dbh in cm</p> <p>Biomass volume is calculated using the allometric equation 3.2.1 for tropical dry biome based on Browns et al. (1989)¹⁴</p> $Y = \exp\{-1.996+2.32*\ln(D)\}$ <p>Where,</p> <p>Y biomass per tree in kg</p> <p>D dbh in cm</p> <p>Biomass volume is calculated using the allometric equation 3.2.5</p>

³¹ 3. METHODS FOR ESTIMATING BIOMASS DENSITY FROM EXISTING DATA (fao.org)

	for tropical wet biome based on Browns et al. (1989) ¹⁴ $Y = 21.297 - 6.953(D) + 0.740(D^2)$ Where, Y biomass per tree in kg D dbh in cm
Description of measurement methods and procedures to be applied	Based and applied on measured DBH values. Volume was derived from the DBH and height measurements which were then multiplied with the Wood density and Biomass expansion factor to calculate the biomass which was then converted to tCO ₂ e / hectare using standard conversion factors.
Frequency of monitoring/recording	Annually
Value applied:	To refer monitoring sheet for A/R activities
Monitoring equipment	The DBH values reported in the farm diary are crosschecked by the field coordinators during periodic inspections
QA/QC procedures to be applied	Monitored using standard techniques as per Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities version 4.2
Purpose of Data	Baseline GHG emissions and removals
Calculation method	Application of allometric aboveground biomass equation
Comments	None

5.3 Monitoring Plan

Agricultural activities in the baseline are assessed and adoption of SALM practices are monitored annually using activity-based model estimates. The data collected and recorded by farmers in the farm diary are the input values to run the RothC carbon model to derive local SOC emission factors, and secondly to determine the area under SALM adoption. Furthermore, to the locally monitored field data, available datasets are used to parameterize RothC models separately for IPCC climatic zones. The parameters in the farmer diary are based on the self-assessment of the farmer which is monitored by the VGS staff. The monitoring of the Agroforestry is periodically done by the VGS field staff. The field data including the data from the farm diary are then entered into the pre-defined data collection sheets and the compiled annual sheet is prepared for the monitoring after due QC checks by VGS staff. The Internal inspection and monitoring report is used for internal auditing and QA/QC. At least one internal inspector is nominated per 250 groups of farmers and among this minimum 20% of samples are inspected (on a Rotational Basis) of all farmers/cropland in the group is carried out twice a year. The inspections are carried out in the presence of the member or his/her representatives and include a visit to the farm. The internal inspector verifies whether the internal standards (ALM/SLAM activities/practices) have been followed, and suggestions of the previous internal inspection fulfilled. The visit of the internal inspector is documented in the farm inspection checklist duly signed by the inspector and countersigned by the member or his representative during the day of inspection.

In case of any non-compliance, the results are reported immediately to the Project Manager and all measures are to be taken to close the concerns or issues identified by mutual talks and implementation of practices.

All the farmers shall maintain the farm diary to notify their activities on their farms. Internal inspector checks the Field records (Farm Dairy details including the main cultivation measures, use of organic inputs, pest control, water management, harvested quantities, post-harvest procedure, agro-forestry etc.). The samples of the filled inspection report are submitted to the VVB.

The farm households were interviewed periodically throughout this verification period by the VGS field staff visits to ensure implementation of the SALM practices and recording any deviations. In this project, complete monitoring (full census) of the SALM activities for the use of organic fertilizers, harvested dry matter and tress planted for Agroforestry was done. No stratification approach was applied for these parameters.

PP has conducted a full census for all SALM practices, including Fertilizer Use, Agroforestry, and Residue Management - input data monitoring for the soil model applied to the "Soil Organic Carbon" parameter, in accordance with the ABMS requirements outlined in the VM0017 methodology.

It is stratified to the project area according to the IPCC climate classification into three zones: Tropical Dry, Tropical Moist, and Tropical Wet. Additionally, we have further classified the area based on USDA soil orders, which include Alfisols, Aridisols, Entisols, Inceptisols, Ultisols, and Vertisols. This classification results in a total of 16 different classes within the project area. Specifically, the Tropical Dry zone contains 6 classes, while both the Tropical Moist and Tropical Wet zones each contain 5 classes.

During the verification period, farm households were periodically interviewed by VGS field staff to ensure the correct implementation of Sustainable Agricultural Land Management (SALM) practices and to document any deviations. A full census monitoring approach was employed throughout the project to track key parameters, including the application of synthetic and organic fertilizers, collection of input data for Soil Organic Carbon (SOC) modelling, and the number of trees planted for agroforestry.

For future monitoring and to support ongoing verification activities, the same full census methodology will be applied. This will ensure consistent tracking of fertilizer usage, SOC modelling inputs, and agroforestry implementation, in accordance with the monitoring requirements outlined in VM0017.

For SOC, using the CDM sampling tool, for 95% confidence level and 10% precision, the total number of farms under each of the 16 soil classes were given as inputs for the tool. The tool calculated 132 samples across all soil classes for the Tropical Dry zone, 127 samples for the Tropical Moist zone, and 102 samples for the Tropical Wet zone. This brings the total number of samples to 361, out of a total of 29,739 samples. However, sample size of 397 was taken to consider any sampling errors and comparisons were made to ensure that the samples were within the acceptable standard deviation of 15% when compared with field inventory. The complete sample analysis was submitted to VVB. A similar stratification and sampling approach is to be followed for all instances included in future for subsequent monitoring periods.

As stated in the IPCC GPG for LULUCF (page 4.111) monitoring requires provisions for quality assurance (QA) and quality control (QC) to be implemented via a QA/QC plan. The monitoring plan adopted by VGS covers the following aspects:

1. Collection of reliable field measurements and verifying methods used to collect field data.
2. Verifying data entry and analysis techniques; and
3. Data maintenance and archiving.

Adequate training of the field staff and cross-checking with the data entry ensures that errors are minimized both at the field level and at the data compilation level.

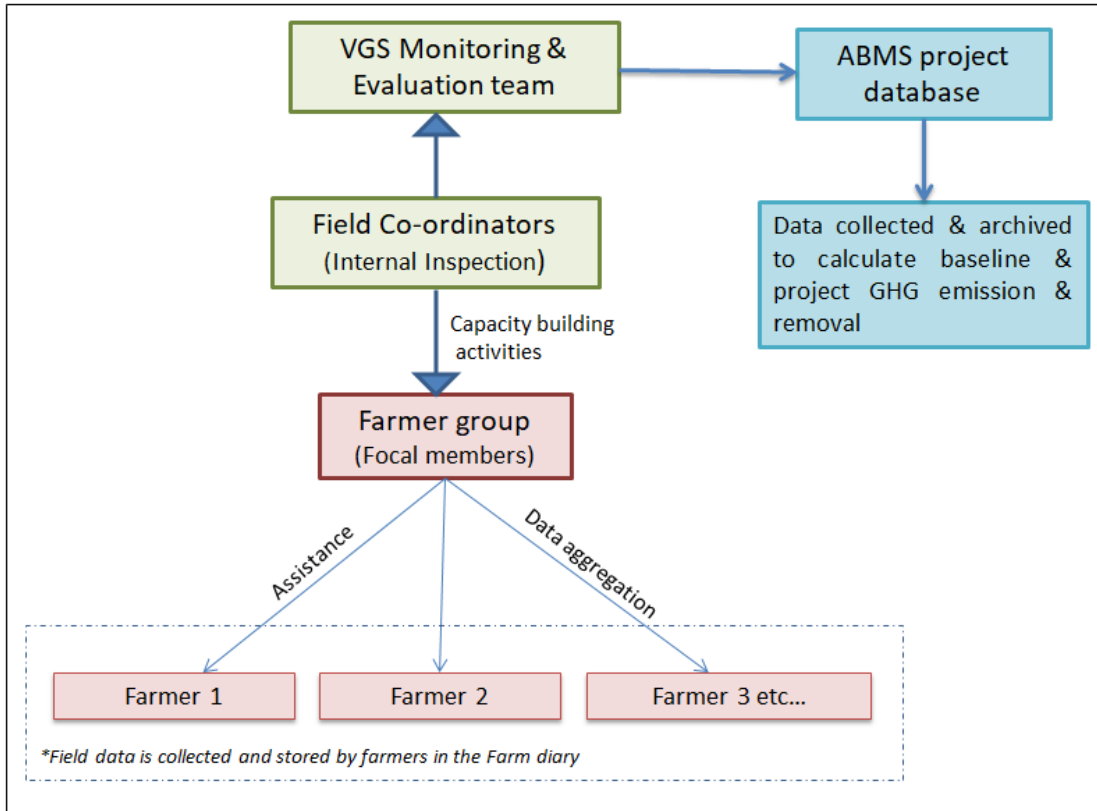


Figure 17: Flow chart representing monitoring plan

6 ACHIEVED GHG EMISSION REDUCTIONS AND REMOVALS

6.1 Data and Parameters Monitored

Data to be collected and archived for project GHG emissions and removals

Data / Parameter	PSN_t
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Data unit	kg/year		
Description	Annual Synthetic fertilizer use		
Source of data	Farm Diary – compiled by VGS monitoring team		
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff		
Frequency of monitoring/recording	Annually		
Value applied:	Year	Synthetic fertilizer usage (Ton)	organic fertilizer usage (Ton)
	1st Oct 2017	5,569	1,367
	2018	15,594	2,015
	2019	12,217	2,403
	2020	10,025	2,670
	2021	6,683	3,205
	30th Sep 2022	10,935	5,826
Monitoring equipment	Farm Diary		
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.		
Purpose of data	Project GHG emissions and removals		
Calculation method	Reported by farmers through farm diary data which is collected annually		
Comments	NA		

Data / Parameter	$PA_{C,t}$
Data unit	ha/year
Description	Areas in cropland under project activity
Source of data	Farm Diary compiled by VGS monitoring team based on information from the farmer and farmer associations. The area under the project activity is cross checked with database from the farmer associations. This is then converted to the KML file demarcating the boundary and point location is also provided for the farm.
Description of measurement methods and procedures to be applied	Farmer self-assessment and cross-check by VGS field staff
Frequency of monitoring/recording	Annually

Value applied:	51,764 hectares
Monitoring equipment	Farm Diary
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	PF_t
Data unit	USD/kg
Description	the price of inorganic fertilizer
Source of data	Based on published reports and information from farmer associations. Fertilizer statistics handbook 2021-2022, published by Fertilizer association of India
Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	Annually
Value applied:	Urea - 5630 INR / ton
Monitoring equipment	NA
QA/QC procedures to be applied	
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	There is no change in the price of urea during the monitoring period

Data / Parameter	$Crop_{i,t}$
Data unit	kg d.m./ha/year
Description	Harvested annual dry matter yield for crop i
Source of data	Farm Diary
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff
Frequency of monitoring/recording	Annually

Value applied:	Year	Harvested annual Dry Matter (Tonne/ha/year)
	1st Oct 2017	38,845
	2018	633,951
	2019	645,231
	2020	649,489
	2021	658,812
	30th Sep 2022	506,462
Monitoring equipment	NA	
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.	
Purpose of data	Project GHG emissions and removals	
Calculation method	Farmers report cropland in hectares.	
Comments	NA	

Data / Parameter	$Area_{i,t}$
Data unit	ha/year
Description	Total seasonal area harvested of crop I
Source of data	Farm Diary compiled by VGS monitoring team based on information from the farmer and farmer associations. The area under the project activity is cross checked with database from the farmer associations. This is then converted to the KML file demarcating the boundary and point location is also provided for the farm.
Description of measurement methods and procedures to be applied	Farmer self-assessment and cross-check by VGS field staff
Frequency of monitoring/recording	Annually
Value applied:	51,764 hectares
Monitoring equipment	Farm diary
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	$Areaburnt_{i,t}$
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Data unit	Ha/ year
Description	Seasonal area of crop I
Source of data	Not Applicable as it is not monitored
Description of measurement methods and procedures to be applied	Not Applicable
Frequency of monitoring/recording	Not Applicable
Value applied:	Not Applicable
Monitoring equipment	NA
QA/QC procedures to be applied	
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	$MB_{C,t}$
Data unit	t d.m./year
Description	Mass of crop residues burnt
Source of data	Not Applicable as it is not monitored
Description of measurement methods and procedures to be applied	Not Applicable
Frequency of monitoring/recording	Not Applicable
Value applied:	Not Applicable
Monitoring equipment	NA
QA/QC procedures to be applied	NA
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	C_F
Data unit	unitless

Description	Combustion factors that depend on vegetation type
Source of data	IPCC value according to guidance of the applied Methodology VM0017
Description of measurement methods and procedures to be applied	n/a
Frequency of monitoring/recording	Project start
Value applied:	Refer to calculation sheet
Monitoring equipment	n/a
QA/QC procedures to be applied	n/a
Purpose of data	Project GHG emissions and removals
Calculation method	The method proposed in the SALM methodology is applied
Comments	Only used if significant

Data / Parameter	FC _{j,t}																												
Data unit	Liters																												
Description	Fossil fuel consumed in vehicle or equipment recorded by vehicle and fuel type																												
Source of data	Monitoring by VGS staff																												
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff																												
Frequency of monitoring/recording	Annually																												
Value applied:	<p>No increase in the use of machinery</p> <table border="1"> <thead> <tr> <th>Year</th> <th>litres/year</th> <th>Crop area</th> <th>litres/ha</th> </tr> </thead> <tbody> <tr> <td>1st OCT 2017</td> <td>60,516</td> <td>51,764</td> <td>1.17</td> </tr> <tr> <td>2018</td> <td>108,929</td> <td>51,764</td> <td>2.10</td> </tr> <tr> <td>2019</td> <td>54,465</td> <td>51,764</td> <td>1.05</td> </tr> <tr> <td>2020</td> <td>27,232</td> <td>51,764</td> <td>0.53</td> </tr> <tr> <td>2021</td> <td>10,212</td> <td>51,764</td> <td>0.20</td> </tr> <tr> <td>30th Sep 2022</td> <td>13,344</td> <td>51,764</td> <td>0.26</td> </tr> </tbody> </table>	Year	litres/year	Crop area	litres/ha	1st OCT 2017	60,516	51,764	1.17	2018	108,929	51,764	2.10	2019	54,465	51,764	1.05	2020	27,232	51,764	0.53	2021	10,212	51,764	0.20	30th Sep 2022	13,344	51,764	0.26
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	compared to the baseline was observed for the monitoring period.																												
Monitoring equipment	Monitoring by VGS staff																												
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.																												

Purpose of data	Project GHG emissions and removals
Calculation method	Farmers report on the use of machinery on cropland. Only applied if significant, increase of machinery used by farmers monitored
Comments	NA

Data / Parameter	$PA_{C,mc}, t$										
Data unit	Hectares										
Description	Project areas in cropland with management practice, mC										
Source of data	Farm diary										
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff										
Frequency of monitoring/recording	Annually										
Value applied:	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>IPCC</th> <th>Crop Area (ha)</th> </tr> </thead> <tbody> <tr> <td>Tropical Dry</td> <td>42,420</td> </tr> <tr> <td>Tropical Moist</td> <td>8,477</td> </tr> <tr> <td>Tropical Wet</td> <td>867</td> </tr> <tr> <td>Total</td> <td>51,764</td> </tr> </tbody> </table>	IPCC	Crop Area (ha)	Tropical Dry	42,420	Tropical Moist	8,477	Tropical Wet	867	Total	51,764
IPCC	Crop Area (ha)										
Tropical Dry	42,420										
Tropical Moist	8,477										
Tropical Wet	867										
Total	51,764										
Monitoring equipment	Farm diary and cross check using GIS maps										
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections. Google Earth is used for validation.										
Purpose of data	Project GHG emissions and removals										
Calculation method	Farmers report all agricultural practices on their farmland as well as the area where these practices are applied.										
Comments	NA										

Data / Parameter	$SOC_{C,mc}, t$
Data unit	tC/ha
Description	Soil organic carbon density, to a depth of 30 cm, at equilibrium for cropland with management practice, mC
Source of data	RothC model

Description of measurement methods and procedures to be applied	Through quantitative analysis, RothC model calculations			
Frequency of monitoring/recording	Modeled for baseline and project scenario for each IPCC zone within a monitoring period. The average SOC across all IPCC zones for 2017-2022 is summarized below.			
Value applied:		IPCC Zone	Average SOC t/C (RothC modelled)	
		Tropical dry	25.43	
		Tropical moist	24.55	
		Tropical wet	19.43	
Monitoring equipment	RothC model worksheet			
QA/QC procedures to be applied	The version of the model has been developed for each IPCC zone.			
Purpose of data	Project GHG emissions and removals			
Calculation method	Modeled with RothC model.			
Comments	NA			

Data / Parameter	$PP_{C,m_c,t}$
Data unit	t/ha/year
Description	Production in cropland per season with management practice from within the project, mC
Source of data	Farm diary
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff
Frequency of monitoring/recording	Annually
Value applied:	Refer monitoring sheet.
Monitoring equipment	Farm diary
QA/QC procedures to be applied	The values reported by farmers are crosschecked by the field coordinators through regular internal inspections.
Purpose of data	Project GHG emissions and removals
Calculation method	NA
Comments	NA

Data / Parameter	$PR_{C,m_c,t}$																																																															
Data unit	tC/ha/season																																																															
Description	Project fraction of production returned as residues per season in cropland with management practice, m_c (calculated from $PP_{C,m_c,t}$)																																																															
Source of data	Farm diary																																																															
Description of measurement methods and procedures to be applied	Farmer self-assessment and cross-check by VGS field staff																																																															
Frequency of monitoring/recording	Annually																																																															
Value applied:	<table border="1"> <thead> <tr> <th colspan="7">crop residue (t/ha/season)</th> </tr> <tr> <th>IPCC Zone</th> <th colspan="2">Tropical dry</th> <th colspan="2">Tropical moist</th> <th colspan="2">Tropical wet</th> </tr> <tr> <th>Year</th> <th>Rabi crop</th> <th>Khari f crop</th> <th>Rabi crop</th> <th>Khari f crop</th> <th>Rabi crop</th> <th>Khari f crop</th> </tr> </thead> <tbody> <tr> <td>1st Oct 2017</td> <td>0.68</td> <td>2.31</td> <td>0.67</td> <td>2.25</td> <td>0.53</td> <td>2.02</td> </tr> <tr> <td>2018</td> <td>0.76</td> <td>2.6</td> <td>0.75</td> <td>2.53</td> <td>0.59</td> <td>2.27</td> </tr> <tr> <td>2019</td> <td>0.8</td> <td>2.75</td> <td>0.78</td> <td>2.69</td> <td>0.62</td> <td>2.41</td> </tr> <tr> <td>2020</td> <td>0.79</td> <td>2.9</td> <td>0.77</td> <td>2.83</td> <td>0.61</td> <td>2.54</td> </tr> <tr> <td>2021</td> <td>0.89</td> <td>3.02</td> <td>0.87</td> <td>2.94</td> <td>0.69</td> <td>2.64</td> </tr> <tr> <td>30th Sep 2022</td> <td>0.92</td> <td>3.13</td> <td>0.9</td> <td>3.05</td> <td>0.71</td> <td>2.73</td> </tr> </tbody> </table>	crop residue (t/ha/season)							IPCC Zone	Tropical dry		Tropical moist		Tropical wet		Year	Rabi crop	Khari f crop	Rabi crop	Khari f crop	Rabi crop	Khari f crop	1st Oct 2017	0.68	2.31	0.67	2.25	0.53	2.02	2018	0.76	2.6	0.75	2.53	0.59	2.27	2019	0.8	2.75	0.78	2.69	0.62	2.41	2020	0.79	2.9	0.77	2.83	0.61	2.54	2021	0.89	3.02	0.87	2.94	0.69	2.64	30th Sep 2022	0.92	3.13	0.9	3.05	0.71	2.73
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Monitoring equipment	Farm Diary - Full census ABMS monitoring approach																																																															
QA/QC procedures to be applied	The values reported by the farmers are crosschecked by the field coordinators through internal inspection at regular intervals.																																																															
Purpose of data	Project GHG emissions and removals																																																															
Calculation method	Calculated from $PP_{C,m_c,t}$ and $PA_{C,m_c,t}$ for residue management																																																															
Comments	NA																																																															

Data / Parameter	$PM_{C,m_c,t}$
Data unit	t/ha/year

Description	Project farmyard manure input in cropland per season with management practice, mC															
Source of data	Farmer Diary – compiled by VGS monitoring team and cross checked.															
Description of measurement methods and procedures to be applied	Farmer self-assessment and monitoring by VGS field staff															
Frequency of monitoring/recording	Annually															
Value applied:	<table border="1"> <thead> <tr> <th>Year</th> <th>FYM (tC/ha/yr)</th> </tr> </thead> <tbody> <tr> <td>1st Oct 2017</td> <td>4,636</td> </tr> <tr> <td>2018</td> <td>18,705</td> </tr> <tr> <td>2019</td> <td>24,939</td> </tr> <tr> <td>2020</td> <td>31,174</td> </tr> <tr> <td>2021</td> <td>37,409</td> </tr> <tr> <td>30th Sep 2022</td> <td>37,409</td> </tr> </tbody> </table>	Year	FYM (tC/ha/yr)	1st Oct 2017	4,636	2018	18,705	2019	24,939	2020	31,174	2021	37,409	30th Sep 2022	37,409	
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30th Sep 2022	37,409															
Monitoring equipment	Farmer diary															
QA/QC procedures to be applied	The farmyard manure input reported by the farmers is crosschecked by the field coordinators during periodic inspection.															
Purpose of data	Project GHG emissions and removals															
Calculation method	NA															
Comments	NA															

Data / Parameter	\overline{Temp}_m																																																
Data unit	°C																																																
Description	Average temperature per month																																																
Source of data	Annual Reports – Government of Karnataka																																																
Description of measurement methods and procedures to be applied	Collected from IMD database <table border="1" style="margin-left: 20px;"> <thead> <tr> <th colspan="6">Tropical dry</th> </tr> <tr> <th>Months</th> <th>2018</th> <th>2019</th> <th>2020</th> <th>2021</th> <th>2022</th> </tr> </thead> <tbody> <tr> <td>Jan</td> <td>22.83</td> <td>22.20</td> <td>24.00</td> <td>23.74</td> <td>24.91</td> </tr> <tr> <td>Feb</td> <td>24.65</td> <td>25.67</td> <td>25.20</td> <td>25.73</td> <td>24.31</td> </tr> <tr> <td>Mar</td> <td>27.95</td> <td>28.77</td> <td>27.33</td> <td>25.61</td> <td>24.52</td> </tr> <tr> <td>Apr</td> <td>30.05</td> <td>30.80</td> <td>29.89</td> <td>24.99</td> <td>24.86</td> </tr> <tr> <td>May</td> <td>29.94</td> <td>29.59</td> <td>30.56</td> <td>24.36</td> <td>24.74</td> </tr> <tr> <td>Jun</td> <td>26.84</td> <td>28.34</td> <td>27.19</td> <td>25.69</td> <td>25.23</td> </tr> </tbody> </table>	Tropical dry						Months	2018	2019	2020	2021	2022	Jan	22.83	22.20	24.00	23.74	24.91	Feb	24.65	25.67	25.20	25.73	24.31	Mar	27.95	28.77	27.33	25.61	24.52	Apr	30.05	30.80	29.89	24.99	24.86	May	29.94	29.59	30.56	24.36	24.74	Jun	26.84	28.34	27.19	25.69	25.23
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Months	2018	2019	2020	2021	2022																																												
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	Jul	25.52	26.18	25.97	25.15	26.11
	Aug	25.04	25.45	25.20	26.20	24.85
	Sep	26.25	25.71	25.71	24.29	25.22
	Oct	26.05	25.68	25.49	25.07	24.81
	Nov	24.87	24.78	24.12	25.03	25.04
	Dec	23.49	23.46	22.79	25.29	25.64
	Tropical moist					
	Months	2018	2019	2020	2021	2022
	Jan	23.60	22.97	24.45	28.60	24.35
	Feb	24.87	25.29	25.22	26.80	25.25
	Mar	27.25	27.24	27.13	23.53	26.38
	Apr	28.69	29.19	28.71	26.93	25.90
	May	27.74	29.11	28.75	24.10	23.28
	Jun	25.09	26.70	25.60	25.45	25.85
	Jul	24.23	24.76	25.07	26.70	26.45
Aug	23.93	24.38	24.22	26.03	24.18	
Sep	25.43	24.90	25.01	27.10	23.53	
Oct	26.22	25.79	25.20	23.45	21.05	
Nov	25.34	25.79	25.45	25.10	22.93	
Dec	24.52	25.12	24.48	24.05	25.23	
Tropical wet						
Months	2018	2019	2020	2021	2022	
Jan	26.53	25.68	26.98	22.18	26.43	
Feb	27.45	27.78	27.78	22.90	24.23	
Mar	29.00	28.78	28.90	26.23	25.10	
Apr	29.98	30.45	30.30	26.58	26.40	
May	28.83	30.68	29.93	24.05	23.68	
Jun	26.50	28.48	27.00	24.83	25.90	
Jul	26.13	26.63	26.48	25.40	25.30	
Aug	25.55	26.33	26.13	25.05	23.80	
Sep	27.18	26.90	26.43	24.80	25.08	
Oct	28.20	27.53	26.63	24.55	27.45	
Nov	27.95	28.20	27.88	26.05	23.98	
Dec	27.08	27.60	27.48	24.93	25.88	
Frequency of monitoring/recording	For each modeled season/year the previous 5 years					
Value applied:	See SOC Calculation sheet					
Monitoring equipment	Input for RothC models					

QA/QC procedures to be applied	Uncertainty analysis. Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of $SOCC,m_c^t$
Purpose of data	Project GHG emissions and removals
Calculation method	Collected from IMD
Comments	NA

Data / Parameter	$Prec_m$																																																																																																																																																																		
Data unit	mm																																																																																																																																																																		
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	Dec	8.38	22.98	15.58	26.75	32.23
	Tropical wet					
	Months	2018	2019	2020	2021	2022
	Jan	0.00	0.00	0.00	72.10	0.23
	Feb	0.55	0.70	0.55	16.23	0.48
	Mar	34.00	3.98	11.18	11.83	28.15
	Apr	48.40	33.18	64.03	91.63	79.88
	May	324.50	30.98	143.08	375.28	282.80
	Jun	1063.15	516.05	732.75	710.63	532.48
	Jul	1120.15	1059.03	887.35	982.25	1480.53
	Aug	1092.73	1378.20	1121.15	505.48	830.48
	Sep	105.45	634.75	769.55	471.93	363.35
	Oct	173.43	482.18	296.15	330.60	158.28
	Nov	22.83	55.68	26.15	238.43	46.08
	Dec	9.95	21.03	12.33	27.60	24.43
Frequency of monitoring/recording	For each modeled season/year the previous 5 years					
Value applied:	See SOC Calculation sheet					
Monitoring equipment	Input for RothC models					
QA/QC procedures to be applied	Uncertainty analysis: Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of $SOC_{C,m}^t$					
Purpose of data	Project GHG emissions and removals					
Calculation method	Collected from IMD					
Comments	NA					

Data / Parameter	\overline{Evap}_m																								
Data unit	mm/day																								
Description	Average evapotranspiration per month																								
Source of data	USGS - Monthly Evapotranspiration data (https://earlywarning.usgs.gov/fews/product/460)																								
Description of measurement methods and procedures to be applied	ET calculated using Operational Simplified Surface Energy Balance (SSEBop) model																								
	Tropical dry																								
	<table border="1"> <tr> <td>Months</td> <td>2018</td> <td>2019</td> <td>2020</td> <td>2021</td> <td>2022</td> </tr> <tr> <td>Jan</td> <td>37.31</td> <td>40.06</td> <td>40.52</td> <td>39.74</td> <td>38.89</td> </tr> <tr> <td>Feb</td> <td>41.58</td> <td>42.51</td> <td>45.61</td> <td>43.26</td> <td>43.58</td> </tr> <tr> <td>Mar</td> <td>50.80</td> <td>59.09</td> <td>55.85</td> <td>57.08</td> <td>54.76</td> </tr> </table>	Months	2018	2019	2020	2021	2022	Jan	37.31	40.06	40.52	39.74	38.89	Feb	41.58	42.51	45.61	43.26	43.58	Mar	50.80	59.09	55.85	57.08	54.76
Months	2018	2019	2020	2021	2022																				
Jan	37.31	40.06	40.52	39.74	38.89																				
Feb	41.58	42.51	45.61	43.26	43.58																				
Mar	50.80	59.09	55.85	57.08	54.76																				

	Apr	50.64	59.18	56.87	55.67	53.88	
	May	50.82	63.31	60.30	57.97	54.56	
	Jun	41.33	50.56	45.91	46.02	46.90	
	Jul	38.52	40.73	36.70	39.38	34.94	
	Aug	39.65	39.89	39.80	41.08	41.12	
	Sep	40.68	36.27	35.97	40.46	37.71	
	Oct	41.80	35.34	38.45	40.05	38.50	
	Nov	36.73	35.42	37.91	35.91	35.96	
	Dec	34.16	33.73	38.08	36.08	34.94	
	Tropical moist						
	Months	2018	2019	2020	2021	2022	
	Jan	38.55	41.39	40.36	40.07	39.35	
Feb	42.43	42.80	45.22	43.15	43.16		
Mar	50.13	57.26	54.16	55.91	54.26		
Apr	48.00	55.53	54.09	53.42	50.31		
May	47.15	59.65	55.23	52.40	47.42		
Jun	35.97	46.27	41.76	41.55	42.21		
Jul	34.31	36.84	34.07	35.96	32.59		
Aug	35.39	36.04	37.07	38.41	38.09		
Sep	40.77	35.25	34.36	38.64	36.60		
Oct	40.79	34.37	37.12	38.83	37.90		
Nov	37.67	36.29	38.36	35.43	36.34		
Dec	34.42	35.32	38.81	36.55	35.84		
Tropical wet							
Months	2018	2019	2020	2021	2022		
Jan	39.79	42.39	40.33	39.98	39.95		
Feb	42.45	42.97	44.34	42.96	42.71		
Mar	49.01	55.96	52.85	54.02	52.69		
Apr	46.49	53.49	52.04	51.79	47.60		
May	45.10	57.93	52.23	49.71	44.08		
Jun	33.04	43.89	38.45	38.74	39.14		
Jul	30.31	32.48	31.54	32.94	30.92		
Aug	32.08	31.85	34.71	36.32	36.37		
Sep	41.65	33.84	32.74	36.90	35.97		
Oct	40.51	33.48	35.95	38.30	38.50		
Nov	38.27	37.42	39.64	35.41	36.96		
Dec	35.01	36.11	39.64	37.14	36.72		
Frequency of monitoring/recording	For each modeled season/year the previous 5 years						
Value applied:	See SOC Calculation sheet						
Monitoring equipment	Input for RothC models						

QA/QC procedures to be applied	Uncertainty analysis. Based on the guidance of the methodology the uncertainty of the climate data is included in the overall estimation of uncertainty of $SOC_{C,m}^t$
Purpose of data	Project GHG emissions and removals
Calculation method	It is calculated from climate data and solar radiation
Comments	NA

Data and parameters collected and archived for use with the CDM tool 'Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities' to calculate change in carbon stock within the project boundary:

Data / Parameter	R_j
Data unit	unitless
Description	Root-shoot ratio for tree species j
Source of data	Based on scientific studies of common native species in India.
Value applied:	0.30
Justification of choice of data or description of measurement methods and procedures applied	<i>Based on scientific studies of common native species in India. Biomass Production and Carbon Sequestration Potential of Different Agroforestry Systems in India: A Critical Review 2022, 13(8), 1274 (source : https://doi.org/10.3390/f13081274)</i>
Purpose of Data	To estimate the Below Ground biomass
Comments	NA

Data / Parameter	$A_{p,i}$
Data unit	ha
Description	Area under agroforestry tree planting
Source of data	Data based on the Number of trees planted in each farm and calculated based on tree density considering a spacing of 3m between each tree.
Value applied:	The Agroforestry activities with planted trees span an area of 5,258 hectares for this monitoring period.
Justification of choice of data or description of measurement methods and procedures applied	N/A

Purpose of Data	Baseline GHG emissions and removals
Comments	NA

Data / Parameter	DBH
Data unit	cm
Description	Diameter at breast height of agroforestry trees (long living trees)
Source of data	Refer calculation sheet based on CDM tool
Value applied:	To refer ABMS monitoring sheet for A/R activities
Justification of choice of data or description of measurement methods and procedures applied	Monitored using standard techniques as per Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities version 2.0. A measurement tape is used to estimate the DBH. For the inventory, all trees with DBH of 10 cm and above were considered.
Purpose of Data	Baseline GHG emissions and removals
Comments	<p>In each farm, the DBH of eligible trees were measured. The trees were selected to ensure that at least one tree under each of the species is covered. After this, measurements were made to ensure at least 10% of the total eligible trees planted were measured. The height of one representative small, medium and large tree were recorded using a clinometer. During the process if noticed that the DBH is not representative of the tree's diameter due to an irregular growth, a second measurement was taken slightly above the growth and the point of measurement was used as opposed to the DBH. If the tree bifurcated below the point of measurement, it was measured as two separate trees.</p> <p>For this monitoring period, 5-year-old planted trees were considered eligible.</p>

Data / Parameter	$f (DBH)$
Data unit	t d.m.

Description	Above- ground biomass (AGB) was calculated using the Allometric equation.
Source of data	<p>Biomass volume is calculated using the allometric equation 3.2.4³³ for tropical moist biome based on Browns et al. (1989)³⁴</p> $Y = \exp\{-2.134+2.530*\ln(D)\}$ <p>Where,</p> <p>Y biomass per tree in kg</p> <p>D dbh in cm</p> <p>Biomass volume is calculated using the allometric equation 3.2.1 for tropical dry biome based on Browns et al. (1989)¹⁴</p> $Y = \exp\{-1.996+2.32*\ln(D)\}$ <p>Where,</p> <p>Y biomass per tree in kg</p> <p>D dbh in cm</p> <p>Biomass volume is calculated using the allometric equation 3.2.5 for tropical wet biome based on Browns et al. (1989)¹⁴</p> $Y = 21.297-6.953(D)+0.740(D^2)$ <p>Where,</p> <p>Y biomass per tree in kg</p> <p>D dbh in cm</p>
Value applied:	To refer ABMS monitoring sheet for A/R activities
Justification of choice of data or description of measurement methods and procedures applied	Monitored using standard techniques as per Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities version 4.2
Purpose of Data	Baseline GHG emissions and removals
Comments	Volume was derived from the DBH and height measurements which were then multiplied with the Wood density and Biomass expansion factor to calculate the biomass which was then converted to tCO ₂ e / hectare using standard conversion factors.

³³ 3. METHODS FOR ESTIMATING BIOMASS DENSITY FROM EXISTING DATA (fao.org)

6.2 Baseline Emissions

Baseline emissions were estimated based on the data recorded during VGS monitoring undertaken prior to the project start date of October 2017 for the total project area. The baseline net GHG removals by sinks are estimated using equation 3 in section II (4.8) of the Approved VCS methodology VM0017 (version 1.0).

The total baseline emissions and removals are given by:

$$BE_t = BEF_t + BEFF_t + BEBB_t - BRWP_t$$

Where

BE_t Baseline emission in year t, t CO₂e

BEF_t Baseline emission due to nitrogen fertilizer use in year t, t CO₂e

$BEFF_t$ Baseline emission due to use of fossil fuels in agricultural management in year t, t CO₂e

$BEBB_t$ Baseline emission due to biomass burning in year t, t CO₂e

$BRWP_t$ Baseline removals due to changes in woody perennials in year t, t CO₂e

6.2.1 Baseline emissions due to inorganic fertilizer use

Baseline emissions from inorganic fertilizer use were monitored from 2017 to 2022 from ABMS fertilizer data, with an average 0.2 tons per hectare. Using the CDM A/R tool for "Estimation of Direct Nitrous Oxide Emissions from Nitrogen Fertilization"³⁵, and applying equations 1 and 2 from the tool, the annual greenhouse gas emissions due to inorganic fertilizer use in the baseline were determined for each year. Consequently, the Baseline Emissions Factor (BEF_t) monitored value applied in the table below.

Table 34 : Data/Parameters used for estimation of the direct nitrous oxide emissions from nitrogen fertilization

Data/Parameter	Unit	Description	Sources	Value applied
EF1	t-N ₂ O-N	Emission Factor for emissions from N inputs	Country-specific data, IPCC	0.01 (Refer IPCC Table 11.1)

³⁵ A/R Methodological tool "Estimation of direct nitrous oxide emission from nitrogen fertilization"

(Version 01) EB 33, Annex 16. <http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-07-v1.pdf>

FracGASF	Dimensionless	The fraction that volatilizes as NH ₃ and NO _x for synthetic fertilizers	Country-specific data, IPCC	0.11 (Refer IPCC Table 11.3)
FracGASM	Dimensionless	The fraction that volatilizes as NH ₃ and NO _x for organic fertilizers	Country-specific data, IPCC	0.21 (Refer IPCC Table 11.3)
FSN,t	t-N yr-1	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x	Estimated	347 kg
FON,t	t-N yr-1	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x	Estimated	Nil
NCSFi	g-N (100 g fertilizer)-1	Nitrogen content of synthetic fertilizer type i applied	Producers of synthetic fertilizer purchased and used	0.4 ³⁶
NCOFj	g-N (100 g fertilizer)-1	Nitrogen content of organic fertilizer type j applied	Organic fertilizer manufacturer, or determination in lab	0.2 ³⁷
MWN2O	tonne-N ₂ O (t-N)-1	Ratio of molecular weights of N ₂ O and N	IPCC default value	44/28

³⁶ <https://sci-hub.arizonastockbroker.com/10.1023/a:1009740530221>

the direct emissions from agricultural soils have been estimated at 2.1 (0.4-3.8) Tg N y⁻¹, with a total from agricultural systems (including emissions from animal production and indirect emissions derived from N of agricultural origin) of 6.3 Tg N y⁻¹ (Mosier et al., 1998).

Closing the global N₂O budget: nitrous oxide emissions through the agricultural nitrogen cycle | 10.1023/a:1009740530221_Sci-Hub 2025

³⁷ Table: 2 - CURRENT IPCC DEFAULT METHOD FOR CALCULATING N₂O EMISSIONS FROM DIRECT SOURCES

Section --> 2.1.1 Process models

Source:https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_5_N2O_Agricultural_Soils.pdf

GWPN20	kg-CO2-e (kg-N2O)-1	Global Warming Potential for N2O	IPCC default value	310
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Table 35 : Baseline emissions due to fertilizer use in this monitoring period

Year	Crop area in ha	Baseline emissions due to fertilizer use, BEF _t (tCO ₂ e)
1st Oct 2017	51,764	9,767
2018	51,764	27,347
2019	51,764	21,425
2020	51,764	17,580
2021	51,764	11,720
30th Sep 2022	51,764	19,177
Total	51,764	107,016

6.2.2 Baseline emissions due to the use of N-fixing species

The ABMS monitoring records that there is no baseline from the use of N-fixing species, since the project area lacking any N-fixing species as agricultural crops in the baseline. Therefore, baseline emissions changes due to the use of N- fixing species are zero, therefore:

$$BEN_t = 0$$

6.2.3 Baseline emissions due to burning of biomass

The project is promoting the cessation of biomass burning and thus emissions due to this practice are expected to decrease within the project. Emissions are not monitored as the project is not claiming emission reductions for this activity. Hence not applicable.

Therefore,

$$BEBB_t = 0$$

6.2.4 Baseline emissions from existing woody perennials

The baseline removals from woody perennials, BRWP t are calculated using the latest version of the CDM A/R tool: Estimation of carbon stocks of trees and shrubs in A/R CDM project activities. Baseline trees need not to be monitored in the baseline. Only new trees added by the project will be considered in the project removals from existing woody perennials conservatively assumed to be zero.

$$BRWP_t = 0$$

6.2.5 Baseline emissions from use of fossil fuels in agricultural management

As per the tool 'Estimation of emissions from combustion the use of fossil fuels in agricultural management' (Section VI.2 of the Methodology) the baseline emission due to the use of fossil fuels which is insignificant compared to the project net anthropogenic GHG removals. Based on the survey of fuel usage at baseline period, 1,403 tCO₂e / year was estimated as the emission from fossil fuel across the crop area of 51,764 ha which gave a usage rate of around 2.09 L/ha/year. In the overall context of the estimated total ex-ante net GHG emissions of 171,399 tCO₂e / year these emissions are found to be insignificant (approximately 1%) and are assumed to be zero in the baseline scenario.

The CO₂ emissions are calculated using the following equations (refer VI.2 Estimation of emissions from the use of fossil fuels in agricultural management of VM0017 methodology, equation 20).

$$ET_{j,t} = FC_{j,t} \times EF_{CO_2,j}$$

Where:

$ET_{j,t}$ Emission from fossil fuel combustion in vehicle/equipment type j during year t , t CO₂e/yr

$FC_{j,t}$ Consumption of fossil fuel in vehicle/equipment type j during year t , liters/yr

$EF_{CO_2,j}$ Emission factor for the type of fossil fuel combusted in vehicle or equipment. For gasoline $EF_{CO_2} = 0.002810$ t per liter. For diesel $EF_{CO_2} = 0.002886$ t per liter

j Type of vehicle/equipment

J Total number of types of vehicle/equipment used in the project activity

The consumption of fossil fuel year wise provided by Project Proponent is as follows:

Table 36: Consumption of fossil fuel (Liters/year)

Year	litres/year	Crop area	litres/ha
2016	486,146	51,764	9.39
1st Oct 2017	60,516	51,764	1.17
2018	108,929	51,764	2.10
2019	54,465	51,764	1.05
2020	27,232	51,764	0.53
2021	10,212	51,764	0.20
30th Sep 2022	13,344	51,764	0.26

Table 37: Emissions from fossil fuel for baseline and monitoring period

Period	Year	tco2eq
Baseline	<u>2016</u>	1403.01
Monitoring	<u>1st Oct 2017</u>	698.6
	<u>2018</u>	314.37

	<u>2019</u>	157.18
	<u>2020</u>	78.59
	<u>2021</u>	39.29
	<u>30th Sep 2022</u>	38.51

The project considers emissions from fossil fuels negligible, as the average annual emissions during the monitoring period are lower than the baseline emissions.

BEFF t = 0

6.2.6 Equilibrium soil organic carbon density in management systems

The SALM management practices promoted by the project are Residue management (Mulching and Cover crops), and Agroforestry. The RothC soil organic model was used for SOC estimations. The monitoring sheets have recorded the field data related to these practices as well as the data required for the RothC model.

$$BS_{equil,t} = \sum_{m_c} BA_{C,m_c,t} \times SOC_{C,m_c} + \sum_{m_G} BA_{G,m_G,t} \times SOC_{G,m_G} \quad (1)$$

Where:

$BS_{equil,t}$	Baseline SOC in equilibrium year t, tC
$BA_{C,m_c,t}$	Baseline areas in cropland with management practices, m_c , year t, ha
SOC_{C,m_c}	Soil organic carbon density at equilibrium for cropland with management practices, m_c , tC/ha
m_c	An index for cropland management types, unit less
$BA_{G,m_G,t}$	Baseline areas in grassland with management practices, m_G , year t, ha
SOC_{G,m_G}	Soil organic carbon density to a depth of 30 cm, at equilibrium for grassland with management practice, m_G , tC/ha
m_G	An index for grassland management types, unit less

6.2.7 Baseline removals due to change in soil organic carbon

Among the SALM management practices implemented by the project the following were considered for soil organic carbon (SOC) estimations Residue management – including both residue mulching and cover crops as the baseline survey indicated that this practice was not common, and the adoption rate was below 1%.

The RothC soil organic carbon model was used for SOC estimations. The baseline survey recorded the area of implementation of these practices in the baseline as well as the data required for the estimation of the corresponding model input parameters. SALM practices that have resulted in the increase of SOC estimations between baseline and project scenarios will result in SOC changes and these changes are considered for the emission reduction calculations.

Since the applicability conditions of the SALM methodology restrict SALM projects to lands that are degrading (see section 3.2 for justification of the degrading nature of soils/lands in the project area), as

per the SALM methodology, baseline removals due to changes in SOC are accounted for as zero.

Therefore $BRS_t = 0$

Where: BRS_t Baseline removals due to changes in soil organic carbon in year t, t CO₂e.

6.2.8 Total baseline emissions and removals

The total baseline emissions and removals are given by equation 3 of the methodology:

$$BE_t = BEF_t + BEFF_t + BEBB_t - BRWP_t$$

Where: BE_t Baseline emissions in year t, t CO₂e

BEF_t Baseline emissions due to nitrogen fertilizer use in year t, t CO₂e.

$BEFF_t$ Baseline emissions due to fossil fuel use in year t, t CO₂e. = 0

$BEBB_t$ Baseline emissions due burning biomass in year t, t CO₂e = 0

$BRWP_t$ Baseline removals due to woody perennials in year t, t CO₂e = 0

Hence,

$$BE_t = BEF_t + 0 + 0 - 0$$

Hence, applying the above justification, only Baseline emissions due to nitrogen fertilizer use are considered as summarized in the table below.

Table 38: Total baseline emissions and removals in the monitoring period

Year	Baseline emissions due to fertilizer use, BEF_t (tCO ₂ e)	Baseline emissions due to fossil fuel use, $BEFF_t$ (tCO ₂ e)	Baseline emissions due to the use of N-fixing species, BEN_t (tCO ₂ e)	Baseline emissions due to biomass burning, $BEBB_t$ (tCO ₂ e)	Baseline removals from existing woody perennials, $BRWP_t$ (tCO ₂ e)	Baseline removals due to changes in soil organic carbon, BRS_t (tCO ₂ e)	Total baseline emissions and removals, BE_t (tCO ₂ e)
1st Oct 2017	9,767	0	0	0	0	0	9,767
2018	27,347	0	0	0	0	0	27,347
2019	21,425	0	0	0	0	0	21,425
2020	17,580	0	0	0	0	0	17,580
2021	11,720	0	0	0	0	0	11,720
30th Sep 2022	19,177	0	0	0	0	0	19,177
Total	107,016	0	0	0	0	0	107,016

6.3 Project Emissions

Project emissions due to fertilizer use

A/R Methodological tool 07 “Estimation of direct nitrous oxide emission from nitrogen fertilization” (Version 01)

The direct nitrous oxide emissions from nitrogen fertilization can be estimated using equations as follows:

$$N_2O_{direct-N,t} = (F_{SN,t} + F_{ON,t}) \times EF_1 \times MW_{N_2O} \times GWP_{N_2O} \quad (1)$$

$$F_{SN,t} = \sum_i^I M_{SFi,t} \times NC_{SFi} \times (1 - Frac_{GASF}) \quad (2)$$

$$F_{ON,t} = \sum_j^J M_{OFj,t} \times NC_{OFj} \times (1 - F_{GASM}) \quad (3)$$

Where:

$N_2O_{direct-N,t}$	Direct N ₂ O emission as a result of nitrogen application within the project boundary, t-CO ₂ -e in year t
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x , t-N in year t
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x , t-N in year t
$M_{SFi,t}$	Mass of synthetic fertilizer type i applied tonne in year t
$M_{OFj,t}$	Mass of Number of synthetic fertilizer types organic fertilizer type j applied, tonne in year t
EF_1	Emission Factor for emissions from N inputs, tonne-N ₂ O-N (t-N input) ⁻¹
$Frac_{GASF}$	Fraction that volatilises as NH ₃ and NO _x for synthetic fertilizers, dimensionless
F_{GASM}	Fraction that volatilises as NH ₃ and NO _x for organic fertilizers, dimensionless
MW_{N_2O}	Ratio of molecular weights of N ₂ O and N (44/28), tonne-N ₂ O (t-N) ⁻¹
GWP_{N_2O}	Global Warming Potential for N ₂ O, kg-CO ₂ -e (kg-N ₂ O) ⁻¹ (IPCC default = 310, valid for the first commitment period)
NC_{SFi}	Nitrogen content of synthetic fertilizer type i applied, g-N (100 g fertilizer) ⁻¹
NC_{OFj}	Nitrogen content of organic fertilizer type j applied, g-N (100 g fertilizer) ⁻¹
I	Number of synthetic fertilizer types
J	Number of organic fertilizer types

Table 39: Data/Parameters used for estimation of the direct nitrous oxide emissions from nitrogen fertilization

Data/Parameter	Unit	Description	Sources	Value applied
EF1	t-N ₂ O-N	Emission Factor for emissions from N inputs	Country-specific data, IPCC	0.01 (Refer IPCC Table 11.1)

FracGASF	Dimensionless	The fraction that volatilizes as NH ₃ and NO _x for synthetic fertilizers	Country-specific data, IPCC	0.11 (Refer IPCC Table 11.3)
FracGASM	Dimensionless	The fraction that volatilizes as NH ₃ and NO _x for organic fertilizers	Country-specific data, IPCC	0.21 (Refer IPCC Table 11.3)
FSN,t	t-N yr-1	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x	Estimated	347 kg
FON,t	t-N yr-1	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH ₃ and NO _x	Estimated	Nil
NCSFi	g-N (100 g fertilizer)-1	Nitrogen content of synthetic fertilizer type i applied	Producers of synthetic fertilizer purchased and used	0.4 ³⁸
NCOFj	g-N (100 g fertilizer)-1	Nitrogen content of organic fertilizer type j applied	Organic fertilizer manufacturer, or determination in lab	0.2 ³⁹
MWN2O	tonne-N ₂ O (t-N)-1	Ratio of molecular	IPCC default value	44/28

³⁸ <https://sci-hub.arizonastockbroker.com/10.1023/a:1009740530221>

the direct emissions from agricultural soils have been estimated at 2.1 (0.4-3.8) Tg N y⁻¹, with a total from agricultural systems (including emissions from animal production and indirect emissions derived from N of agricultural origin) of 6.3 Tg N y⁻¹ (Mosier et al., 1998).

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³⁹ Table: 2 - CURRENT IPCC DEFAULT METHOD FOR CALCULATING N₂O EMISSIONS FROM DIRECT SOURCES

Section --> 2.1.1 Process models

Source:https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_5_N2O_Agricultural_Soils.pdf

		weights of N ₂ O and N		
GWPN ₂ O	kg-CO ₂ -e (kg-N ₂ O)-1	Global Warming Potential for N ₂ O	IPCC default value	310

The project does not endorse the use of synthetic fertilizers. Instead, it promotes the adoption of SALM practices, which aim to improve soil fertility and reduce dependence on synthetic fertilizers. In the baseline scenario, the use of synthetic fertilizers was recorded, with emissions calculated at 18,251 tCO₂e per hectare of crop land annually. The PEFT values were derived from the ABMS monitoring sheet, which tracks organic fertilizer usage. The Nitrogen Content of fertilizer applied 0.5 [NC_{fertiliser} - 0.5 Producers of synthetic fertilizer purchased and used. For organic fertilizers, from manufacturer or determination in lab]. The evidence has been submitted to VVB. The total crop area for the three IPCC zones amounts to 51,764 hectares, which was considered in the final PEFT calculation. Ex-post estimates are provided on the table below.

Table 40: Total ex-post estimation of project emissions due to fertilizer use

Year	Crop area in ha	Project emissions due to fertilizer use, PEFT (tCO ₂ e)
1st Oct 2017	51,764	1,065
2018	51,764	1,577
2019	51,764	1,873
2020	51,764	2,081
2021	51,764	2,498
30th Sep 2022	51,764	4,541
Total	51,764	13,635

Project emissions due to the use of N-fixing species

Estimate of project emissions due to the increased use of N-fixing species in year t, t CO₂e: As it is not considered in the project activity, it is not applicable.

Therefore, for ex-post estimation, it is accounted as zero.

$$PEN_t = 0$$

Project emissions due to the burning of biomass

Estimate of project emissions due to biomass burning in year t, t CO₂e: As the project activity does not consider any emission reductions from avoidance of biomass burning, it is not applicable.

Therefore, for ex-post estimation, it is accounted as zero.

PEFF t= 0

Project removals from woody perennials

A mix of recommended Agroforestry tree species were planted, and the tree growth was accounted by means of an inventory conducted after the end of the 5-year monitoring period based on the eligibility criteria of minimum DBH of 10 cm.

10% of the project area is under agroforestry based on the project design. Each farmland contains a variety of species, and the full census of the average tree circumference was measured across three IPCC climate zones.

Above Ground Biomass (AGB) was calculated using the allometric equation 3.2.1 for tropical dry biomes, as defined by Brown et al. (1989):

$$Y = \exp \{-1.996 + 2.32 \times \ln(D)\}$$

Where:

Y = Biomass per tree (kg)

D = Diameter at breast height (DBH in cm)

Above Ground Biomass (AGB) was calculated using the allometric equation 3.2.4 for tropical moist biome based on Browns et al. (1989)¹⁴

$$Y = \exp\{-2.134+2.530*\ln(D)\}$$

Where,

Y biomass per tree in kg

D dbh in cm

Above Ground Biomass (AGB) was calculated the allometric equation 3.2.5 for tropical wet biome based on Browns et al. (1989)¹⁴

$$Y = 21.297-6.953(D)+0.740(D^2)$$

Where,

Y biomass per tree in kg

D dbh in cm

Different allometric equations were applied for each IPCC zone to estimate AGB. Below Ground Biomass (BGB) was calculated using a conversion factor of 0.30, based on scientific studies of common native species in India (Biomass Production and Carbon Sequestration Potential of Different Agroforestry Systems in India: A Critical Review, 2022, 13(8), 1274).

Estimate of project removals due to changes in biomass of woody perennials in year t, t CO₂e: the changes in the agroforestry trees are measured and the change in biomass calculated using the latest version of the CDM A/R tool: Estimation of carbon stocks of trees and shrubs in A/R CDM project activities.

The following equations were used based on the Tool 14:

$$C_{TREE} = \frac{44}{12} \times CF_{TREE} \times B_{TREE} \quad (\text{Equation 12})$$

$$B_{TREE} = A \times b_{TREE} \quad (\text{Equation 13})$$

$$b_{TREE} = \sum_{i=1}^M W_i \times b_{TREE,i} \quad (\text{Equation 14})$$

C_{TREE} = Carbon stock in trees in the tree biomass estimation strata; t CO₂e

CF_{TREE} = Carbon fraction of tree biomass; t C (t d.m.)⁻¹. A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value.

B_{TREE} = Tree biomass in the tree biomass estimation strata; t d.m.

A = Sum of areas of the tree biomass estimation strata; ha

b_{TREE} = Mean tree biomass per hectare in the tree biomass estimation strata; t d.m. ha⁻¹

W_i = Ratio of the area of stratum i to the sum of areas of tree biomass estimation strata (i.e./); dimensionless

$b_{TREE,i}$ = Mean tree biomass per hectare in stratum i; t d.m. ha⁻¹

Uncertainty was calculated in accordance with Appendix 2 of the A/R Methodological Tool. As the uncertainty of woody perennials across the three IPCC zones is 5%, no discount factor was applied. Carbon stock in tons per hectare was estimated for each IPCC zone. The ABMS Agroforestry sheet has been submitted to the VVB for verification.

The project has considered the removals from woody perennials at the end of the 5th year monitoring period. For ex-post estimation, PRWP_t was calculated as 67,218 tCO₂e as summarized in the Table below.

Table 41: Total Ex-post estimates for project removals from woody perennials

Year	Agroforestry area in ha	Project removals from existing woody perennials, PRWP _t (tCO ₂ e)
1st Oct 2017	5,258	-
2018	5,258	-

2019	5,258	-
2020	5,258	-
2021	5,258	-
30th Sep 2022	5,258	67,218
Total	5,258	67,218

Project emissions due to use of fossil fuels for agricultural management

As typical small-scale farmers, the farmer groups involved in this project use fossil fuel-based machinery (diesel/petrol) for agricultural operations and the rate of usage did not vary much after the project implementation. Monitoring of fossil fuel use based on the different farm machinery use was reported during this monitoring period. For comparison, in the project area, recorded data for the baseline showed an average annual diesel consumption of 45,783 liters for farm machinery use. Based on the tool "Estimation of emissions from combustion of fossil fuels in agricultural management" (Section 6.2 of the Methodology), this resulted in GHG emissions of approximately 1,403 tCO₂e per year.

Estimate of project emissions due to burning of fossil fuels for agricultural management in year t, tCO₂e:

Based on calculations described in Table 43, it is observed that there is no net increase in the use of fossil fuels, used for farm machinery during project implementation. Hence, the project considers emissions from fossil fuels insignificant, as the average annual emissions during the monitoring period are lower than the baseline emissions.

Table 42: Fossil fuels usage for crop area

Year	litres/year	Crop area	litres/ha
<u>2016 (baseline)</u>	486,146	51,764	9.39
<u>1st OCT 2017</u>	60,516	51,764	1.17
<u>2018</u>	108,929	51,764	2.10
<u>2019</u>	54,465	51,764	1.05
<u>2020</u>	27,232	51,764	0.53
<u>2021</u>	10,212	51,764	0.20
<u>30th Sep 2022</u>	13,344	51,764	0.26

Table 43: Project emissions due to use of fossil fuels for agricultural management

Period	Year	tco2eq
Baseline	<u>2016</u>	1,403
Monitoring	<u>1st Oct 2017</u>	699
	<u>2018</u>	314
	<u>2019</u>	157
	<u>2020</u>	79
	<u>2021</u>	39

	30th Sep 2022	39
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Therefore, for ex-post estimation, it is accounted as zero.

PEFF t= 0

Project equilibrium soil organic carbon density in management systems

The RothC soil organic carbon model is used for SOC change calculations.

Project removals from changes in Soil Organic Carbon (SOC) have been estimated using the RothC carbon model. The model input parameter for the different SALM practices were assessed as follows using data recorded by the field samples. All input parameters are calculated in relation to the entire adoption area represented by the total cropland in 5 years of the monitoring period. which simulates SOC dynamics based on inputs from crop residues and organic amendments. The RothC model calculates changes in SOC over time resulting from land management practices that influence organic matter inputs.

The model parameters have been set using climate data sourced from local meteorological stations in Karnataka, and soil characteristics derived from laboratory analysis of the project's soil database. Inputs from crop residues and farmyard manure (FYM) have been obtained from ongoing project monitoring data, which are compiled and analyzed in the ABMS monitoring sheet.

The RothC model predicts changes in SOC under the following conditions:

- When there is a variation in input parameters, such as increased incorporation of crop residues or FYM into the soil.
- When there is an expansion in the area under Sustainable Agricultural Land Management (SALM) practices, for example, increased adoption of residue management by participating farmers.

The following studies have been selected to demonstrate that the application of the RothC model is appropriate and that the model is validated for IPCC climate regions.

Summary of RothC model planning and implementation details in the **Appendix 1**

Soil Organic Carbon Modeling

The carbon stock changes in the soil due to a change of management practices in the project area are calculated by using a model approach. RothC software provides a comprehensive framework for simulating soil organic carbon (SOC) turnover using the Rothamsted Carbon (RothC) model. The step-by-step instructions to ensure consistent and accurate modelling of SOC dynamics under various land-use and management scenarios.

Soil carbon input

Among the Sustainable Agricultural Land Management (SALM) practices promoted under the project, the following have been considered for accounting project removals through changes in soil organic carbon, as they contribute to carbon inputs into the soil:

1. **Residue Management** – Incorporation of crop residues into the soil and their use as mulch, enhancing soil carbon levels.

2. **Farmyard Manuring** – Application and incorporation of farmyard manure, contributing organic carbon to the soil.

Five distinct cropping seasons/patterns were identified across three IPCC zones:

1. Kharif
2. Kharif/Rabi
3. Kharif/Rabi/Summer
4. Zaid/Summer
5. Perennial

Based on these identified cropping patterns/seasons, crop residue and FYM (Farmyard Manure) inputs were integrated into the model accordingly.

1. Residue Management Project Scenario:

In organic agricultural⁴⁰ systems, the management of plant residues plays a critical role in maintaining ecological balance and enhancing soil health. Rather than burning or discarding residues, organic farming encourages their strategic use—primarily for livestock feeding and as mulch material returned to the field. Mulching with crop residues improves soil organic carbon (SOC), conserves moisture, suppresses weed growth, and enhances microbial activity, all of which contribute to long-term soil fertility and crop resilience. Residues such as cereal straws, pulse husks, and leguminous haulms are particularly valued for their nutrient content and ease of decomposition.

To accurately reflect these practices in SOC modelling, the crop residues left over in the field after the harvest of Rabi, Kharif, perennial, and summer (Zaid) season crops were incorporated into the RothC model. This inclusion helps in simulating the contribution of crop residues to the soil carbon pool across different seasons, ensuring a more realistic representation of on-ground organic matter dynamics.

The inputs which applied to estimate the uncertainty of the soil modeling. The estimation and value used are contained in the ABMS Excel.

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1. ⁴⁰ Bhattacharyya, R., et al. (2015)
 “Soil organic carbon stocks and stock changes in organic and conventional cropping systems in India.”
 – Demonstrates improved SOC from residue return in organic plots.
 ☞ <https://doi.org/10.1016/j.agee.2015.07.013>
 2. Kumar, V., et al. (2014)
 “Management of crop residues for sustainable crop production: a review.”
 – Highlights residue mulching as a best practice in organic and conservation agriculture.
 ☞ <https://www.sciencedirect.com/science/article/pii/S2095311914603771>
 3. IFOAM (International Federation of Organic Agriculture Movements)
 “Principles of Organic Agriculture”
 – Encourages recycling of biomass to maintain soil fertility and ecological balance.
 ☞ <https://www.ifoam.bio/why-organic/principles-organic-agriculture>
 4. FAO (2017). “Crop Residue Management in Organic Systems”
 – Promotes integration of livestock and use of legume residues for nutrient cycling.
 ☞ <http://www.fao.org/agriculture/organic-agriculture/oa-guidelines/en/>
 5. Verma, B.C., et al. (2012)
 “Nutrient recycling and carbon sequestration through residue incorporation in organic farming systems.”
 – Quantifies carbon retention and improved nutrient availability from residue use.
 ☞ Available via ResearchGate or Indian Journal of Agricultural Sciences.

2. Farmyard Manuring

Farmyard Manure (FYM) has been traditionally used in crop areas, and in recent years, its benefits to farmers have been increasingly emphasized, particularly in the context of sustainable and organic farming practices. The utilization of FYM in crop areas has played a pivotal role in enhancing crop yields, improving soil health, and increasing economic returns for farmers. Its integration into farming practices—especially within organic and sustainable agriculture systems—highlights its value as a key input for promoting agricultural productivity and long-term soil sustainability in the region.

By providing essential nutrients and improving soil physical, chemical, and biological properties, FYM can significantly reduce the need for synthetic fertilizers, resulting in cost savings and environmental benefits. In the current model, FYM application is explicitly incorporated for the sowing months of each agricultural season, tailored for all three IPCC agro-ecological zones represented in the project area. This zonal and season-specific inclusion ensures that the nutrient contribution of FYM is accurately accounted for in the estimation of soil organic carbon (SOC) changes, reflecting realistic farmer practices across diverse climatic conditions.

The inputs which applied to estimate the uncertainty of the soil modeling. The estimation and value used are contained in the ABMS Excel.

The project soil organic carbon at equilibrium can be estimated using:

$$PS_{equil,t} = \sum_{m_c} PA_{C,m_c,t} \times SOC_{C,m_c,t} + \sum_{m_g} PA_{G,m_g,t} \times SOC_{G,m_g,t} \quad (4)$$

Where:

$PS_{equil,t}$	Project SOC in equilibrium year t, tC
$PA_{C,m_c,t}$	Project areas in cropland with management practices, m_c , year t, ha
$SOC_{C,m_c,t}$	Soil organic carbon density at equilibrium for cropland, to a depth of 30 cm, with management practices, m_c , at year t, tC/ha
m_c	An index for cropland management types, unit less
$PA_{G,m_g,t}$	Project areas in grassland with management practices, m_g , year t, ha
$SOC_{G,m_g,t}$	Soil organic carbon density at equilibrium, to a depth of 30 cm, for grassland with management practice, m_g , at year t, tC/ha
m_g	An index for grassland management types, unit less

RothC Validation

There must be studies (for example: scientific journals, university theses, local research studies or work carried out by the project proponent) that demonstrate that the use of the Roth-C model is appropriate for: (a) the IPCC climatic regions of 2006 IPCC AFOLU Guidelines, or (b) the agroecological zone (AEZ) in which the project is situated.

The project area exhibits diverse geographic and physiographic conditions, ranging from arid and semi-arid zones in the plateau region to subhumid and humid tropical climates in the Ghats ⁴¹. According to the IPCC climate classification ⁴², the project area spans three climatic zones: Tropical Dry (82% of the area), Tropical Moist (16.33%) and Tropical Wet (1.67%).

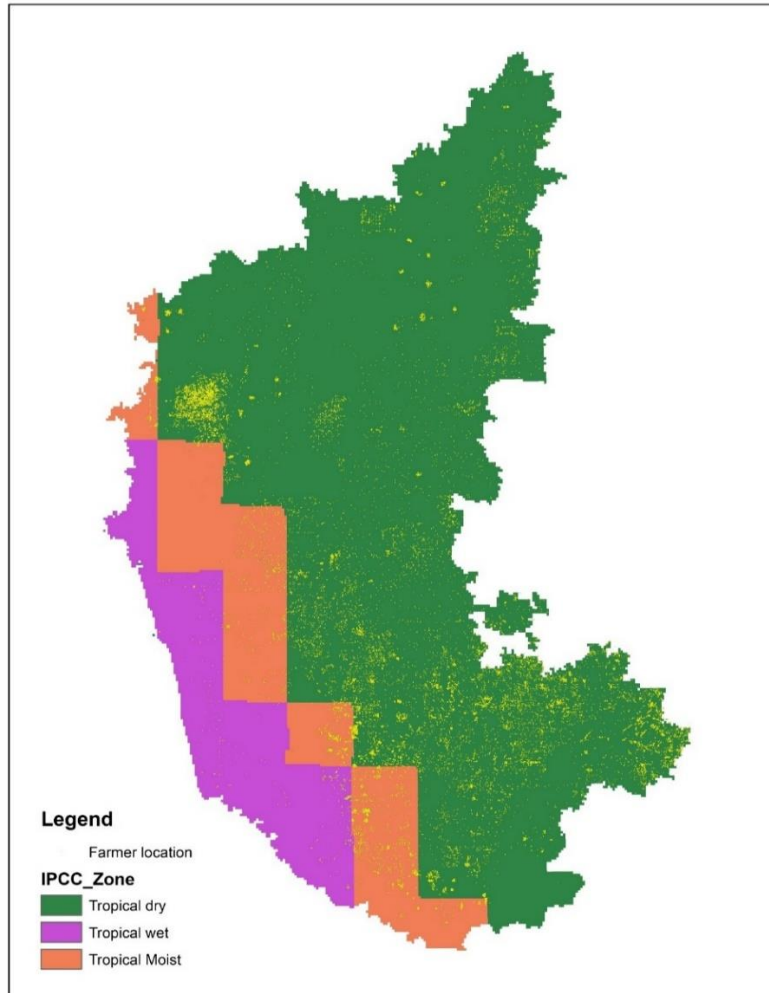


Figure 18: Map of IPCC zones covering Karnataka

Based on USDA classification soil taxonomy⁴³, the primary soil orders found in the project area include Alfisols, Inceptisols, Entisols, Vertisols, Aridisols, and Ultisols.

Table 44: Percentage of project area covering different soil orders

Soil Order	Project area covers (%)
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⁴¹https://wgbis.ces.iisc.ac.in/energy/paper/TR109/tr109_std2.htm#:~:text=Adjoining%20to%20this%20in%20the,arid%20areas%20of%20the%20country.

⁴² <https://philipaudebert.users.earthengine.app/view/ipcc-climate-zones>

⁴³ [Soil Classification Indian Commentary.pdf](#)

Alfisols	38.47
Aridisols	1.58
Entisols	26.13
Inceptisols	24.32
Ultisols	1.20
Vertisols	8.31

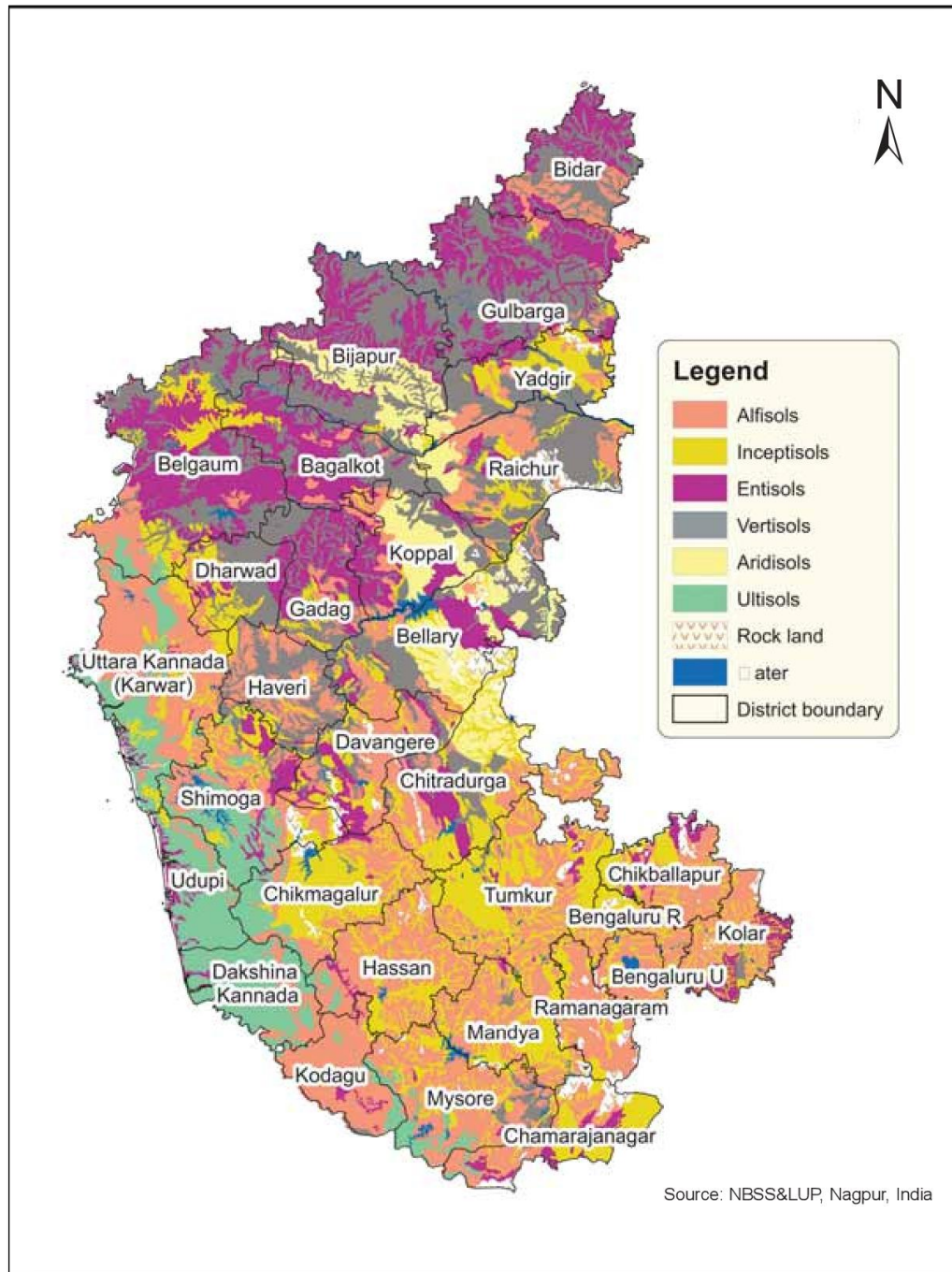


Figure 19: Soil order map of the Project area

The following studies have been selected to demonstrate that the application of the RothC model is appropriate and that the model is validated for IPCC climate regions.

Study 1: "Simulating Change in Soil Organic Carbon in Two Long-Term Fertilizer Experiments in India: The RothC Model" (Bhattacharyya et al., 2013):⁴⁴

This study examined the impact of long-term fertilizer treatments on soil organic carbon (SOC) at two agricultural sites in India: Mohanpur (humid, Tropical Moist) and Akola (semi-arid, Tropical Dry)⁴⁵. The soils at these sites were Alfisols (Mohanpur) and Vertisols (Akola). The RothC model was applied to simulate SOC stock changes under various fertilizer treatments, including organic and inorganic amendments. The results demonstrated that the RothC model effectively predicted SOC stock variations, with minimal simulation bias (relative error, M). This study validates the model's applicability for agricultural research in both tropical and semi-arid regions.

Study 2: "Simulating Soil Organic Carbon Stock Under Different Climate Change Scenarios: A RothC Model Application to Typical Land-Use Systems of Goa, India" (Paramesh et al., 2022):⁴⁶

This research assessed the effects of climate change on SOC stocks across various land-use systems in Goa, India, which spans the Tropical Wet and Tropical Moist zones⁴⁷. The study included soils such as Entisols, Alfisols, Ultisols, and Inceptisols. It concluded that cashew plantations were the most effective system for SOC sequestration, while coconut and pasture lands were less efficient in storing carbon. The RothC model simulations highlighted the potential of agroforestry systems, including cashew, arecanut, coconut, and pasture, for enhancing SOC storage. The findings reinforce the model's potential for supporting sustainable land management and climate resilience in tropical coastal ecosystems.

The soils identified in both studies—Alfisols, Vertisols, Entisols, Ultisols, and Inceptisols—are also present within the project area, further validating the RothC model's relevance. The model has demonstrated strong performance across diverse tropical and subtropical climates, with varied soil types and land uses. It has been successfully used in regions with similar climatic zones (Dry, Moist, and Wet) and soil orders (Alfisols, Inceptisols, Vertisols), which align closely with those in the project area. Given its proven ability to simulate SOC

⁴⁴

https://www.researchgate.net/publication/274546754_Simulating_change_in_soil_organic_carbon_in_two_long_term_fertilizer_experiments_in_India_with_the_Roth_C_model

⁴⁵ Refer to the IPCC Global Map at the following link: [IPCC Climate Zones](#)

⁴⁶ <https://www.sciencedirect.com/science/article/abs/pii/S0341816222001151>

⁴⁷ Refer to the IPCC Global Map at the following link: [IPCC Climate Zones](#)

changes under these conditions, the RothC model is well-suited to assess soil organic carbon dynamics and support sustainable land management practices within the project area.

Project estimate of soil organic carbon with transitions:

The estimate of soil organic carbon with transitions is calculated using the equation 5 of the methodology,

$$PS_t = \frac{1}{D} \sum_{t-D+1}^t PS_{equil,t} \times \Delta t \quad (5)$$

Where:

PS_t	Estimate of the project SOC in year t, tC
$PS_{equil,t}$	Estimate of the project SOC in equilibrium year t, tC
D	The transition period required for SOC to be at equilibrium after a change in land use or management practice, year
Δt	Time increment = 1 year

Project removals due to changes in soil organic carbon:

The project area is stratified, the sampling effort should represent the relevant strata in the sample frame. Where there is no specific survey guidance from national institutions, the project proponent shall use a precision of 15% at the 95% confidence level as the criteria for reliability of sampling efforts. This reliability specification shall be applied to determine the sampling requirements for assessing parameter values. A sample size of 397 was taken to consider any sampling errors and comparisons were made to ensure that the samples were within the acceptable standard deviation of 5% when compared with field inventory. The samples run different aspects like baseline calibration, project intervention calibration, validation, projection of baseline scenario and application after incorporating the interventions (refer Appendix 1).

The estimation of project removals due to changes in SOC is done using the following equation, which is the result of equation 6 of the methodology:

The estimate of project removals due to changes in soil organic carbon is given by:

$$PRS_t = (PS_t - PS_{t-1}) \times \frac{44}{12} \quad (6)$$

Where:

PRS_t	Estimate of project removals due to changes in soil organic carbon in year t, t CO _{2e}
PS_t	Estimate of the project SOC in year t, tC
PS_{t-1}	Estimate of the project SOC in the year t-1, tC

Table 45: Project removals due to changes soil organic carbon in this monitoring period

Year	Crop area in ha	Project removals due to changes in soil organic carbon, PRS _t (tCO ₂ e)
1st Oct 2017	51,764	-
2018	51,764	-
2019	51,764	230,462
2020	51,764	234,051
2021	51,764	238,825
30th Sep 2022	51,764	252,695
Total	51,764	956,032

Uncertainty:

To address uncertainty of the RothC model outputs, the SALM methodology recommends calculating the soil model response using the model input parameters with the upper and lower confidence levels (P_{min} and P_{max} values) as shown in equation 12 and 13 of the methodology:

Step 1: Calculate the values for all input parameters at the upper and lower confidence limit.

The maximum and minimum values of the input parameters at the upper and lower confidence limit were calculated for crop residue, FYM values found in ABMS and for weather parameters (temperature, precipitation and evapotranspiration) and clay content.

Standard error for all the parameters are calculated by using equation 12 of methodology:

$$SE_p = \frac{\partial_p}{\sqrt{n_p}} \quad (12)$$

Where:

SE_p Standard error in the mean of parameter, p in year t

∂_p The standard deviation of the parameter p in year t

n_p Number of samples used to calculate the mean and standard deviation of parameter p

Assuming that the values of the parameters are normally distributed about the mean, the minimum and maximum values for the parameters are calculated by using equation 13 of the methodology:

$$P_{min} = \bar{X}_p - 1.96 * SE_p \quad (13)$$

$$P_{max} = \bar{X}_p + 1.96 * SE_p$$

Where:

P_{min} The minimum value of the parameter at the 95% confidence interval

P_{max} The maximum value of the parameter at the 95% confidence interval

SE_p Standard error in the mean of parameter, p in year t

\bar{X}_p The value of the cumulative normal distribution at 95% confidence interval

Step 2: Calculate the project removals due to changes in soil organic carbon with the minimum and maximum values of the input parameters.

Project removals due to changes in soil organic carbon using the maximum and minimum values of the input parameters determined by using the equation 14 of the methodology

$PRS_{min,t} = Model(P_{min}, Temperature_{max}, Precipitation_{max}, CalyCaontent_{min})$		(14)
$PRS_{max,t} = Model(P_{max}, Temperature_{min}, Precipitation_{min}, CalyCaontent_{max})$		
Where:		
$PRS_{min,t}$	The minimum value of project removals due to changes in soil organic carbon at the 95% confidence interval	
$PRS_{max,t}$	The maximum value of project removals due to changes in soil organic carbon at the 95% confidence interval	

Step 3: Calculate the uncertainty of the model output

The range of model responses demonstrates the uncertainty of the soil modelling, calculated with equation 15 of the methodology:

$$UNC_t = \frac{|PRS_{max,t} - PRS_{min,t}|}{2 * PRS_t} \quad (15)$$

$PRS_{max,t}$ The maximum value of project removals due to changes in soil organic carbon at the 95% confidence interval

$PRS_{min,t}$ The minimum value of project removals due to changes in soil organic carbon at the 95% confidence interval

PRS_t Estimate of project removals due to changes in soil organic carbon in year t, t CO₂e.

The calculated uncertainty of the model output for the current monitoring period found more than 15 % only for tropical moist zone among 3 IPCC zones, hence the estimated value for the tropical moist zone subjected to deductions.

Table 46 :Calculation of the uncertainty in the model output for Tropical dry zone

Tropical Dry					
SL_No	Year(t)	PRSt tco2e	PRSt _{max} (tco2e)	PRSt _{min} (tco2e)	UNCt (%)
1	1st Oct 2017	-	0.00	0.00	0%
2	2018	0.00	0.00	0.00	0%

3	2019	190727.72	223198.57	174277.88	13%
4	2020	193205.31	227298.04	175743.20	13%
5	2021	198611.33	233559.10	179578.70	14%
6	30th Sep 2022	208511.64	217587.11	163379.60	13%

Table 47: Calculation of the uncertainty in the model output for Tropical moist zone

Tropical Moist					
SL_No	Year(t)	PRSt tco2e	PRSt _{max} (tco2e)	PRSt _{min} (tco2e)	UNC _t (%)
1	1st Oct 2017	0.00	0.00	0.00	0%
2	2018	0.00	0.00	0.00	0%
3	2019	36801.63	45198.57	29838.05	21%
4	2020	37869.44	45930.87	30961.04	20%
5	2021	37126.92	46831.50	30285.12	22%
6	30th Sep 2022	40822.84	50513.85	32971.81	21%

Table 48: Calculation of the uncertainty in the model output for Tropical wet zone

Tropical Wet					
SL_No	Year(t)	PRSt tco2e	PRSt _{max} (tco2e)	PRSt _{min} (tco2e)	UNC _t (%)
1	1st Oct 2017	0.00	0.00	0.00	0%
2	2018	0.00	0.00	0.00	0%
3	2019	2932.22	3112.92	2487.21	11%
4	2020	2975.79	3210.40	2507.36	12%
5	2021	3086.63	3340.96	2586.24	12%
6	30th Sep 2022	3360.83	3775.47	2788.87	15%

Step 4: Adjust the estimate of soil sequestration based on the uncertainty in the model output.

The RothC model, operated through a software interface, was used to manually calculate the overall uncertainty. In cases where the uncertainty of the modeled Soil Organic Carbon (SOC) change (PRSt) is less than 15%, the full amount of estimated project removals is accounted for. If the uncertainty exceeds 15%, a discount is applied to the modeled PRSt as per Step 4 of Section IV.2.8 of the SALM methodology.

For this monitoring period, the calculated uncertainty of the model output is less than 15% for tropical dry and tropical wet zones. But for tropical moist zone the calculated uncertainty is more than 15%, hence according equation 16 & 17 of the methodology deductions are applied only for tropical moist zone.

$$PRSt_{Deductions} = PRSt_t \times (UNC_t - 15\%) \quad (16)$$

Table 49: Calculation of the deductions for Tropical dry zone

Tropical Dry					
SL_No	Year(t)	PRSt tco2e	UNCt	15%	PRSDeduction,t due to SOC tCO2e
1	1st Oct 2017	-	0%	15%	0
2	2018	0.00	0%	15%	0
3	2019	190727.72	13%	15%	0.00
4	2020	193205.31	13%	15%	0.00
5	2021	198611.33	14%	15%	0.00
6	30th Sep 2022	208511.64	13%	15%	0.00
	Total	791055.99			0.00

Table 50: Calculation of the deductions for Tropical moist zone

Tropical Moist					
SL_No	Year(t)	PRSt tco2e	UNCt	15%	PRSDeduction,t due to SOC tCO2e
1	1st Oct 2017	0.00	0%	15%	0
2	2018	0.00	0%	15%	0
3	2019	36801.63	21%	15%	2160.01
4	2020	37869.44	20%	15%	1804.50
5	2021	37126.92	22%	15%	2704.15
6	30th Sep 2022	40822.84	21%	15%	2647.59
	Total	152620.84			9316.26

Table 51: Calculation of the deductions for Tropical wet zone

Tropical Wet					
SL_No	Year(t)	PRSt tco2e	UNCt	15%	PRSDeduction,t due to SOC tCO2e
1	1st Oct 2017	0.00	0%	15%	0
2	2018	0.00	0%	15%	0
3	2019	2932.22	11%	15%	0.00
4	2020	2975.79	12%	15%	0.00
5	2021	3086.63	12%	15%	0.00
6	30th Sep 2022	3360.83	15%	15%	0.00
	Total	12355.47			0.00

$$PR_{S_{Adj,t}} = PR_{S_t} - PR_{S_{Deductions}} \quad (17)$$

Where,

PR_{S_t} Estimate of project removals due to changes in soil organic carbon in year t, t CO₂e.

$PR_{S_{Deductions}}$ A calculated deduction to the estimate of the change in soil organic removals year t, t CO₂e

$PR_{S_{Adj,t}}$ An adjusted estimate of project removals due to changes in soil organic carbon in year t, t CO₂e.

The uncertainty was estimated using equations 14-17 and the calculations worksheet has been submitted to VVB.

Table 52: Adjusted estimate of project removals due to change in soil organic carbon for tropical dry zone

Tropical Dry				
SL_No	Year(t)	PR _{S_t} tCO ₂ e	PR _{S_{Deduction,t}} due to SOC tCO ₂ e	PR _{S_{Adj, t}} for uncertainty due to SOC tCO ₂ e
1	1st Oct 2017	0.00	0.00	0.00
2	2018	0.00	0.00	0.00
3	2019	190727.72	0.00	190727.72
4	2020	193205.31	0.00	193205.31
5	2021	198611.33	0.00	198611.33
6	30th Sep 2022	208511.64	0.00	208511.64
	Total	791055.99	0.00	791055.99

Table 53: Adjusted estimate of project removals due to change in soil organic carbon for tropical moist zone

Tropical Moist				
SL_No	Year(t)	PR _{S_t} tCO ₂ e	PR _{S_{Deduction,t}} due to SOC tCO ₂ e	PR _{S_{Adj, t}} for uncertainty due to SOC tCO ₂ e
1	1st Oct 2017	0.00	0.00	0.00
2	2018	0.00	0.00	0.00
3	2019	36801.63	2160.01	34641.62
4	2020	37869.44	1804.50	36064.94
5	2021	37126.92	2704.15	34422.77
6	30th Sep 2022	40822.84	2647.59	38175.25
	Total	152620.84	9316.26	143304.58

Table 54: Adjusted estimate of project removals due to change in soil organic carbon for tropical wet zone

Tropical Wet				
SL_No	Year(t)	PRSt tco2e	PRSDeduction,t due to SOC tCO2e	PRSA _{Adj, t} for uncertainty due to SOC tCO2e
1	1st Oct 2017	0.00	0.00	0.00
2	2018	0.00	0.00	0.00
3	2019	2932.22	0.00	2932.22
4	2020	2975.79	0.00	2975.79
5	2021	3086.63	0.00	3086.63
6	30th Sep 2022	3360.83	0.00	3360.83
	Total	12355.47	0.00	12355.47

Table 55: Project removals due to changes soil organic carbon after deduction in this monitoring period

Year	Crop area in ha	Project removals due to changes in soil organic carbon, PRSt (tCO2e)	PRSDeduction,t due to SOC tCO2e	PRSA _{Adj, t} for uncertainty due to SOC tCO2e
1st Oct 2017	51,764	-	-	-
2018	51,764	-	-	-
2019	51,764	230,462	2,160	228,302
2020	51,764	234,051	1,805	232,246
2021	51,764	238,825	2,704	236,121
30th Sep 2022	51,764	252,695	2,648	250,048
Total	51,764	956,032	9,316.26	946,716

Therefore, total project removals due to changes in soil organic carbon after adjusting the uncertainty (ex-post estimation) as follows:

$$PRSt_{Adj} = 946,716 \text{ tCO}_2\text{e}$$

Total ex-post actual net GHG emissions and removals by sinks for the verification period

The actual net GHG removals by sinks are estimated using the equation in section III (1.9) of the Approved VCS methodology VM0017 (Version 1.0). The actual net GHG removals by sinks are calculated using equation 7 of the methodology.

$$PE_t = PEF_t + PEFF_t + PEN_t + PEBB_t - PRWP_t - PRS_t$$

Where,

PE_t Estimate of actual net project GHG emissions and removals by sinks in year t, t CO₂e

PEF_t Estimate of project emissions due to nitrogen fertilizer use in year t, t CO₂e

PEFF_t Estimate of project emissions due to burning of fossil fuels for agricultural management in year t, t CO₂e = 0

PEN_t Estimate of project emissions due to the increase use of N-fixing species in year t, t CO₂e = 0

$PEBB_t$ Estimate of project emissions due to biomass burning in year t, t CO₂e = 0

$PRWP_t$ Estimate of project removals due to changes in biomass of woody perennials in year t, t CO₂e

PRS_t Estimate of project removals due to change in soil organic carbon in year t, t CO₂e.

The ex-post actual net GHG emissions and removals by sinks are presented in Table 56 for the entire project.

Table 56: Ex-post actual net project GHG emissions and removals by sinks

Year	Project emissions due to fertilizer use, PEF_t (tCO ₂ e)	Project emissions due to fossil fuel use, $PEFF_t$ (tCO ₂ e)	Project emissions due to the use of N-fixing species, PEN_t (tCO ₂ e)	Project emissions due to biomass burning, $PEBB_t$ (tCO ₂ e)	Project removals from existing woody perennials, $PRWP_t$ (tCO ₂ e)	Project removals due to changes in soil organic carbon, PRS_t (tCO ₂ e)	Total project emissions and removals, PE_t (tCO ₂ e)
1st Oct 2017	1,065	0	0	0	0	0	1,065
2018	1,577	0	0	0	0	0	1,577
2019	1,873	0	0	0	0	228302	-226,429
2020	2,081	0	0	0	0	232246	-230,165
2021	2,498	0	0	0	0	236121	-233,623
30th Sep 2022	4,541	0	0	0	67218	250048	-312,725
Total	13,635	0	0	0	67,218	946,716	-1,000,299

6.4 Leakage

Leakage is not applicable for this project as monitored during the verification period. The land is being used for cultivation of crops. Hence there is no shift in activities viz., grazing, fuel wood collection for cooking etc.

As per the methodology, leakage from a switch to non-renewable biomass use or fossil fuels is the possible source of leakage. In the project, the organic manure is used, and any shift occurs within the farm boundary. Hence the leakage, ex-post is estimated as 0. The methodology further states that If the ABMS survey data show that 10% or fewer project households use non-renewable biomass from outside the project or fossil fuels to replace the biomass diverted to agricultural fields, then the leakage is considered insignificant and ignored. In the project, there is no diversion of the biomass as the crop residues which were earlier burnt are recycled back to the soil to increase the organic content. This was verified from the survey data and from periodic interviews with the farmers. Hence leakage is considered zero.

Therefore:

$LHE_t = 0$

6.5 Net GHG Emission Reductions and Removals

The estimation of net anthropogenic GHG removal by sink is made using equation 8 of the methodology VM0017 (version 1.0)

$$\Delta R_t = BE_t - PE_t - LHE_t$$

Where,

ΔR_t Estimate of net anthropogenic GHG emissions and removals in year t, t CO₂e

PE_t Estimate of actual net project GHG emissions and removals in year t, t CO₂e

BE_t Baseline emissions and removals in year t, t CO₂e

LHE_t the leakage from a switch to non-renewable biomass or fossil fuel in place of the biomass used for cooking /heating diverted to agricultural system in year t, t CO₂ e

The total Net GHG emissions generated for this monitoring period are summarized in the table below.

The ex-post estimation of net anthropogenic GHG removals shown in Table 57 and the net emissions reductions, i.e., the number of GHG credits eligible for issuance are shown in Table 58.

Table 57: The total net GHG emissions generated for monitoring period

Year	Baseline emissions or removals - BE _t (tCO ₂ e)	Project emissions or removals - PE _t (tCO ₂ e)	Leakage emissions - LHE _t (tCO ₂ e)	Net GHG emission reductions or removals - ΔR _t (tCO ₂ e)
1st Oct 2017	9,767	1,065	0	8,701
2018	27,347	1,577	0	25,770
2019	21,425	-226,429	0	247,854
2020	17,580	-230,165	0	247,745
2021	11,720	-233,623	0	245,343
30th Sep 2022	19,177	-312,725	0	331,902
Total	107,016	-1,000,299	0	1,107,315

Table 58: Calculation of tradeable VCUs based on applied buffer

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)	NPRR Buffer %	Buffer pool allocation	VCUs eligible for Issuance
1st Oct 2017	9,767	1,065	0	8,701	10%	870	7,831
2018	27,347	1,577	0	25,770	10%	2,577	23,193
2019	21,425	-226,429	0	247,854	10%	24,785	223,068
2020	17,580	-230,165	0	247,745	10%	24,774	222,970
2021	11,720	-233,623	0	245,343	10%	24,534	220,809
30th Sep 2022	19,177	-312,725	0	331,902	10%	33,190	298,712
Total	107,016	1,000,299	0	1,107,315		110,732	996,584

The total net anthropogenic GHG removals and sinks in this monitoring period are 1,107,315tCO₂e (Table 58). The applicable uncertainty has been considered for the claimed emission reduction and wherever applicable the conservative values have been applied. There are no deviations from the monitoring requirements of the methodology for this verification period. Considering these aspects the overall accuracy of the calculated GHG emission reductions and removals for the initial instances are within acceptable limits. The non-permanence risk rating is 10% – as assessed and documented in the Non-Permanence Risk Report (provided as a separate document). Applying this risk rating to the net carbon stock change as per the VCS requirement, the total number of buffer credits that need to be deposited into the AFOLU pooled buffer account is 110,732tCO₂e. Therefore, the number of GHG credits eligible to be issued as VCUs in this monitoring period is 996,584tCO₂e.

APPENDIX 1

Summary of RothC model planning and implementation details-Verra 3115

The carbon stock changes in the soil due to a change of management practices in the project area are calculated by using a model approach. RothC software provides a comprehensive framework for simulating soil organic carbon (SOC) turnover using the Rothamsted Carbon (RothC) model. The step-by-step instructions to ensure consistent and accurate modelling of SOC dynamics under various land-use and management scenarios.

The RothC model (Coleman et al., 2014) simulates the turnover of organic carbon in topsoil, considering the influence of soil type, temperature, moisture, and vegetation cover. It operates on a monthly time step (Coleman and Jenkinson, 1996). RothC divides soil organic carbon (SOC) into five distinct pools: Decomposable Plant Material (DPM), Resistant Plant Material (RPM), Microbial Biomass (BIO), Humified Organic Matter (HUM), and Inert Organic Matter (IOM). Each of these pools decomposes at a unique rate.

During each time step, SOC dynamics are driven by the decomposition of fresh organic inputs—primarily plant residues—partitioned according to a DPM/RPM ratio. These inputs feed the microbial biomass (BIO) and contribute to the slower forming humified organic matter (HUM). The decomposition of each pool is governed by its initial SOC content, adjusted for clay content, environmental modifiers (temperature, moisture, and soil cover), and its specific degradation rate.

Time Period Breakdown

The **soil carbon modelling** using the **RothC model** (a model used to estimate changes in soil organic carbon) is being structured over five distinct time periods. Each period has a specific purpose in building, calibrating, validating, baseline scenario and applying the model to assess the impact of sustainable agricultural practices.

- Soil carbon must be measured at the beginning (baseline) and at least five years after the start of the new practices (this helps in detecting real change).
- If direct measurement isn't possible, a control site (where no new practice was applied) must be used.
- The experiment must include at least one improved agricultural practice (like leaving more crop residues or adding organic matter like farmyard manure) that affects carbon input into the soil.
- These carbon inputs must be clearly described in the model documentation.

1. 2016 to 2017: Baseline Calibration Period

Initial soil carbon data is collected from field before any project practices are applied. This helps calibrate the model to reflect conditions existing prior to start date of project.

2. 2018: Practice change Calibration Period

Project agricultural practices specific to SOC quantification such as crop residue and FYM (Farmyard manure) inputs are monitored in the project area. Data from this period helps to recalibrate the model to account for the project practices. The data used for model calibration and validation are separate.

3. 2019 & 2020: Practice change Validation Period (1st and 2nd Year)

Model predictions are validated against actual field data to check the model's accuracy.

4. 2017 to 2047 Baseline Scenario

The model is applied to estimate changes in soil carbon over time over a period of 5 years, projected for a total of 30 years, Simulates TOC assuming no practice changes only weather data incorporated into the model. Reflects how TOC would have changed without any improved practices – i.e., under conventional farming or land use.

5. 2018 to 2047: Project Scenario

The model is applied to estimate changes in soil carbon over time over a period of 5 years, projected for a total of 30 years. Simulates TOC in the same time period, weather data and for the project area where sustainable practices (Crop residue and farmyard manure(FYM)) were applied.

Detailed review of SOC modelling table attached below

Table 59: Summary of RothC model planning and implementation details

SL- No	Year	Period	Comparison of samples	Activity/Process/Goodness of fit
1	2015 to 2017	Baseline calibration period	Comparison of RothC-modelled SOC values (2016-2017) with average field-observed SOC data for the same year.	To establish baseline trend without practice change; goodness of fit is not applicable
2	2018	Practice change calibration period	RothC-modelled SOC (based on 2018 weather data, crop residue and FYM inputs) vs. observed SOC in 2018.	Independent validation of the model's predictive accuracy using RMSE and R ² Goodness of fit
3	2019 & 2020	Practice change validation period	RothC-modelled SOC for 2019 (with continued residue input and FYM) vs. observed SOC data for 2019. Similarly, RothC-modelled SOC for 2020 vs. observed SOC values for 2020 at sample locations.	Independent validation of the model's predictive accuracy using RMSE and R ²
4	2017- 2067	Baseline period (No Intervention)	Simulated change in SOC from 2017 to 2022 assuming <i>no crop residue and FYM application</i> (business-as-usual).	To establish baseline trend without practice change; goodness of fit is not applicable
5	2018- 2068	Application period (Interventions applied)	Comparison of SOC in 2022 under project scenario (with interventions- crop residue and FYM) vs. simulated 2022 baseline.	Uncertainty based on Equation 15 of VM0017 methodology.

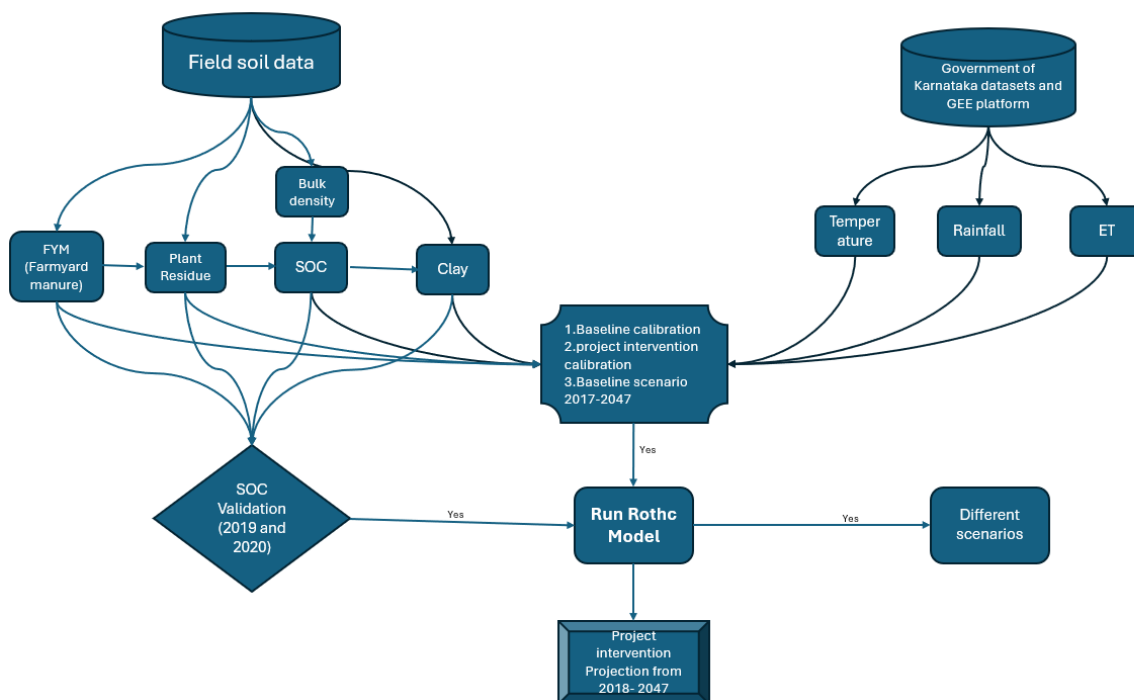


Figure 20: Flow chart - General methodological framework RothC model

Step 1: Field measured data conversion from total organic carbon (%) to Soil organic carbon (t/ha).

This explains how to convert Total Organic Carbon (TOC) measured in the field as a percentage into Soil Organic Carbon (SOC) stock in tonnes per hectare (tC/ha). The method uses bulk density values sourced from geospatial datasets and applies a standard formula based on soil volume.

Table 60: Field measured data conversion from total organic carbon (%) to Soil organic carbon (t/ha).

Total Organic Carbon (%)	Bulk density (g/cm ³)	Soil Organic Carbon in tonnes of carbon per hectare	
		Soil Organic Carbon	Mass of soil in a given volume (bulk density (g/cm ³)*soil depth (30 cm)
0.59	1.215	0.0059	21.51

Example Values Used

- Total Organic Carbon (%) = 0.59%
- SOC fraction = 0.0059 (converted from %)

- Bulk Density = 1.215 g/cm³ (from OpenLandMap data⁴⁸)
- Soil Depth = 30 cm = 0.3 m
- Area = 10,000 m² (1 hectare)

Conversion Formula

$$\text{SOC (t/ha)} = \text{SOC fraction} \times \text{Bulk Density} \times \text{Soil Depth} \times 10,000$$

$$\text{SOC (t/ha)} = 0.0059 \times 1.215 \times 0.3 \times 10,000 = 21.51 \text{ tC/ha}$$

This formula calculates the total mass of soil organic carbon stored in the top 30 cm of soil over one hectare. The SOC fraction is multiplied by the soil bulk density and depth and scaled up to per hectare by multiplying by 10,000 (the number of square meters in a hectare). Thus, the resulting SOC stock is 21.51 tonnes of carbon per hectare for the example given.

Step 2: Sampling selection of farmers using IPCC zone

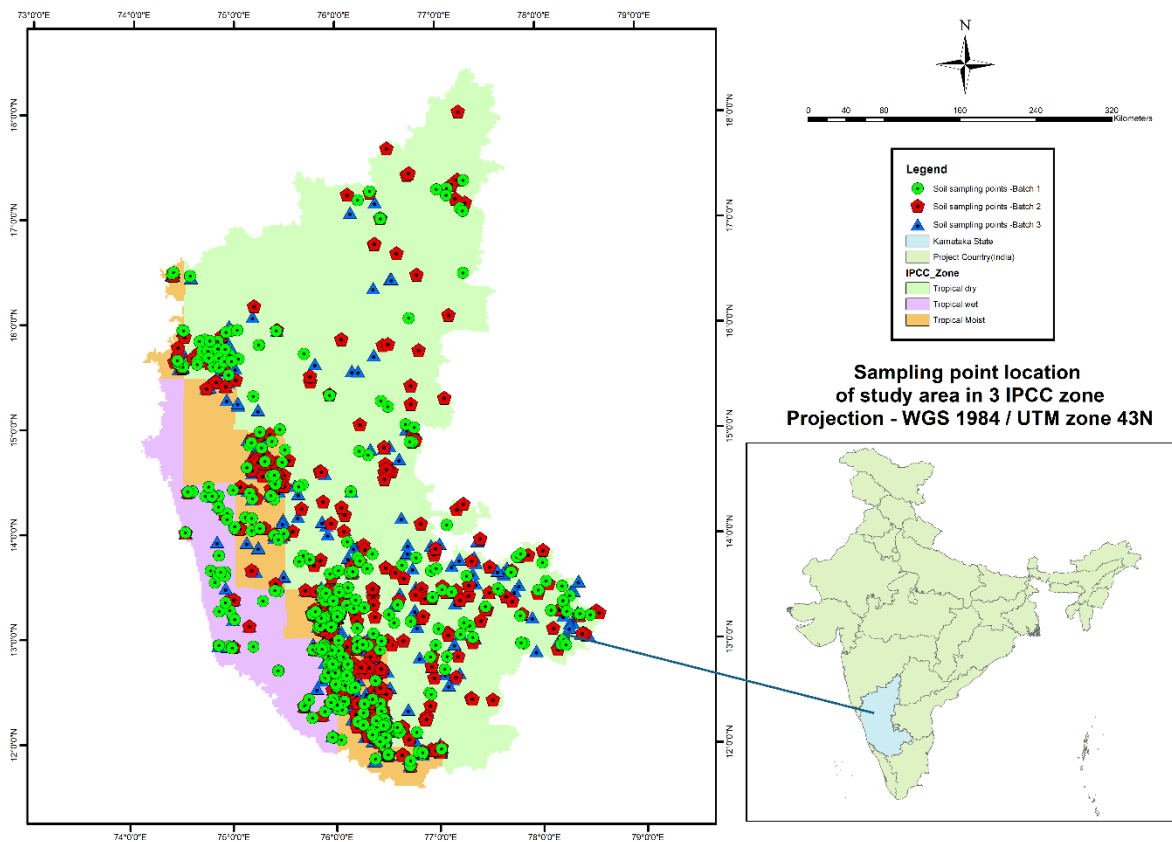


Figure 21: Map of samples selected from 3 IPCC zones of Karnataka

It is stratified to the project area according to the IPCC climate classification into three zones: Tropical Dry, Tropical Moist, and Tropical Wet. Additionally, we have further classified the area

⁴⁸ https://developers.google.com/earthengine/datasets/catalog/OpenLandMap_SOL_SOL_CLAY-WFRACTION_USDA-3A1A1A_M_v02

based on USDA soil orders, which include Alfisols, Aridisols, Entisols, Inceptisols, Ultisols, and Vertisols. This classification results in a total of 16 different classes within the project area. Specifically, the Tropical Dry zone contains 6 classes, while both the Tropical Moist and Tropical Wet zones each contain 5 classes.

Using the CDM sampling tool, for 95% confidence level and 10% precision the total number of farms under each of the 16 strata were given as input for the sampling units.

- The tool calculated 132 samples for the Tropical Dry zone, 127 samples for the Tropical Moist zone, and 102 samples for the Tropical Wet zone. This brings the total number of samples to 361, out of a total of 29,739 farmers. However, sample size of 397 was taken to consider for baseline calibration, practice change calibration, and the application period (Batch 1).
- For the year 2019 and 2020 validation period, approximately 730 samples across different locations in Karnataka, spanning 3 IPCC zones (Batch 2 and Batch 3).

Table 61: Samples used for RothC calibration, validation and application

Sample Batch	Justification
Batch 1 Samples	Among 3 IPCC zones across Karnataka the field measured values were used for baseline calibration(2016&2017), practice change calibration(2018), future projections up to 2047 for baseline and project practice change.
Batch 2 Samples	Covers samples from 3 IPCC zones for the validation period of 2019.
Batch 3 Samples	Covers samples from 3 IPCC zones for the validation period of 2020.

Step 3: Data requirement for RothC model

The RothC model requires the following input data:

- **Weather:** average air temperature, rainfall, and potential evapotranspiration.
- **Soil:** depth of the soil layer, soil cover condition (bare or vegetated), clay percentage, and initial SOC stock (usually derived from soil organic carbon measurements and bulk density).
- **Carbon inputs:** total carbon added from crop residues and farmyard manure(FYM).

Table 62: Input data required for RothC model

Variable	Units	Data Source
Monthly rainfall	mm	https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+(ARC)/Reports/en (Refer: Annual Reports 2016-2022)
Monthly evaporation	mm	https://developers.google.com/earth-engine/datasets/catalog/IDAHO_EPSCOR_TERRACLIMATE
Average monthly mean air temperature	°C	https://empri.karnataka.gov.in/uploads/media_to_upload1691669377.pdf (Refer pg:69-70 year: 2016-2022)
Clay content of the soil	%	https://developers.google.com/earth-engine/datasets/catalog/OpenLandMap_SOL_SOL_CLAY-WFRACTION_USDA-3A1A1A_M_v02
An estimate of the decomposability of the incoming plant material - the DPM/RPM ratio.	None	1.44 (For most agricultural crops and improved grassland, we use a DPM/RPM ratio of 1.44, i.e. 59% of the plant material is DPM and 41%) ⁴⁹
Soil cover (0 or 1)	None	https://agritech.tnau.ac.in/expert_system/paddy/season.html (Refer: Karnataka)

⁴⁹ <https://www.rothamsted.ac.uk/media/8/download>

Step 4: Download RothC software for window

Download RothC software for window from the following link (version2.1) <https://www.rothamsted.ac.uk/rothamsted-carbon-model-rothc>. To run the interface, double click on the RothC Interface icon you will get the screen below:

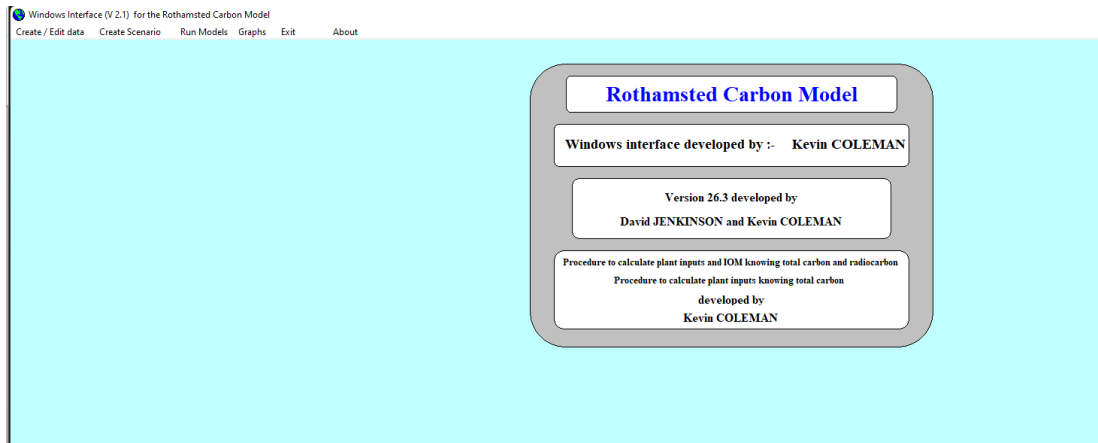


Figure 22: RothC software download from website

Step 5: Input data preparation

- a. **Weather Data:**
 - Gathered monthly data for average temperature ($^{\circ}\text{C}$), precipitation (mm), and potential evapotranspiration (mm).
- b. **Soil Data:**
 - Determined the clay content (%) and initial SOC stock (t C/ha).
- c. **Land Use and Management Data:**
 - Identified the land use type (e.g., grassland, cropland) and management practices.

For the baseline period, weather data collected is from the year 2012-2016(as per VM0017 methodology previous 5 years weather data), while for project scenarios, weather data is taken from the years 2018-2022.

Edit existing weather data			
Save Cancel			
Description	Tropical Dry		
	Temperature (oC) (range)	Rainfall (mm) (range)	Evaporation (mm) (range)
January	23.15	0.86	42.2
February	25.27	2.44	45.58
March	28.44	11.47	57.56
April	29.82	44.73	56.13
May	29.78	70.11	61.69
June	27.09	95	47.95
July	25.61	133.8	41.19
August	25.54	110.1	42.79
September	25.96	121.1	40.61
October	25.97	96.12	42.62
November	24.07	42.82	37.82
December	23.14	7.09	38.47
Clay % (range)	35	Depth (cm) (range)	30

Figure 23: Creation of weather data in RothC model

Step 6: Plant residue and FYM input per month

During the baseline(2016-2017) and monitoring period (2017 to 2022), the Project Proponent (PP) provided data on crop residue and FYM inputs, representing the monthly carbon additions to soil (in t C ha⁻¹). Crop residues are used for feeding livestock, both in the baseline as well as in under project implementation remaining crop residue left on the field after harvest as incorporated into the model. These inputs account for both above-ground residues and carbon released from roots during crop growth and were successfully incorporated into the RothC model.

Table 63: Total crop residue generated and its usage in Karif season

Karif season				
Stages	Total number of samples used with measured value	Residue Generated tC/ha	Used as Fodder 40(%) including all 3 IPCC zones tC/ha	Left on the land & used as mulching 60(%) including all 3 IPCC zones tC/ha
Baseline Scenario(calibration and projection) 2016-2017	397	1226.316	350.376	875.94
Practice change calibration 2018	397	1245.132	355.752	889.38
Validation for 2019 & 2020	730	2822.68	806.48	2016.2

Table 64: Total crop residue generated and its usage in Rabi season

Rabi Season				
Stages	Total number of samples used with measured value	Residue Generated tC/ha	Used as Fodder 70(%) including all 3 IPCC zones tC/ha	Left on the land & used as mulching 30(%) including all 3 IPCC zones tC/ha
Baseline Scenario(calibration and projection) 2016-2017	397	640.951	263.921	377.03
Practice change calibration 2018	397	763.045	314.195	448.85
Validation for 2019 & 2020	730	1400.715	576.765	823.95

Table 65: Various crop considered for quantification of crop residue

Kharif crops			
GREENGRAM	ARECANUT	FINGER MILLET	RAGI
BENGALGRAM	GROUNDNUT	GINGER	REDGRAM
POTATO	NAVANE	GROUND NUT	SOYABIN
ARKA MILLET	ARECANUT	LEAMON	SUGARCANE
HORESEGRAM	ARKA MILLET	MAIZE	TURMERIC
RAGI	BANANA	MIXED VEGETABLES	PAPPER
PROSO MILLET	CHILLIES	ONION	POTATO
COFFEE	COFFEE	PADDY	COWPEA
MAIZE	COTTON	REDGRAM	

Rabi Crops
GREENGRAM
GROUND NUT
JOWAR
PULSES
VEGETABLES

The residue input values are calculated as area-weighted means, already adjusted to reflect the actual field application of residues. Specifically, the total residue carbon from various crops is modified based

on the proportion of area where residues were retained on the field. Farmyard manure (FYM) is a type of organic fertilizer consisting of decomposed mixture of cattle dung, urine, farm litter (like straw), and leftover fodder. It is a rich source of organic matter and nutrients like nitrogen (N), phosphorus (P), and potassium (K) (the typical range percentage of NPK nutrition values considered 0.4, 0.2 0.3 respectively and organic carbon content about 9%.⁵⁰), and it improves soil fertility and structure. These proportions are derived from the annual ABMS (Annual Baseline Monitoring Survey) data, ensuring that the model accurately reflects on-ground residue management practices.

Five distinct cropping seasons/patterns were identified across three IPCC zones:

1. Kharif
2. Kharif/Rabi
3. Kharif/Rabi/Summer
4. Zaid/Summer
5. Perennial

Based on these identified cropping patterns/seasons, crop residue and FYM (Farmyard Manure) inputs were integrated into the model accordingly.

⁵⁰ ICAR – Indian Institute of Soil Science (Bhopal), Regional Data on Organic Inputs

→ NPK & carbon content based on cattle dung compost trials in South India.

UAS Dharwad & UAS Bangalore (Soil Science Depts)

→ FYM application trials and compost nutrient recovery analysis (2000–2020).

Organic Farming Research Centre (ICAR–NBSS&LUP), Bengaluru

→ Report on “Organic Inputs and Soil Health in Karnataka,” 2018.

Example: For all farmers following type of cropping pattern, crop residue & FYM inputs were given as follows

Kharif - Primary crop + Rabi - Secondary crop			Kharif - Primary crop (OR) Rabi - Secondary crop			Kharif - Primary crop (OR) Rabi - Secondary crop (OR) Summer			Perennial season			Zaid/Summer		
Month	Crop residue	FYM	Month	Crop residue	FYM	Month	Crop residue	FYM	Month	Crop residue	FYM	Month	Crop residue	FYM
Jan		0	Jan	Yes(Kharif AH)	0	Jan		0	Jan		0	Jan	Yes(Kharif AH)	0
Feb	YES(Rabbi AH)	0	Feb	YES(Rabbi AH)	0	Feb	YES(Rabbi AH)	0	Feb	0	YES	Feb	YES(Rabbi AH)	0
Mar	YES(Rabbi AH)	0	Mar	YES(Rabbi AH)	0	Mar	YES(Rabbi AH)	0	Mar	0	YES	Mar	YES(Rabbi AH)	0
Apr	NA	NA	Apr	NA	NA	Apr	NA	NA	Apr	NA	NA	Apr	0	YES
May	NA	NA	May	NA	NA	May	NA	NA	May	NA	NA	May	0	YES
Jun	0	YES	Jun	0	Yes	Jun	0	Yes	Jun	0	0	Jun	0	0
Jul	0	YES	Jul	0	0	Jul	0	0	Jul	0	0	Jul	0	0
Aug	0	YES	Aug	0	0	Aug	Yes(Kharif AH)	0	Aug	0	0	Aug	0	0
Sep	0	0	Sep	0	Yes	Sep	0	0	Sep	0	0	Sep	0	0
Oct	Yes(Kharif AH)	YES	Oct	Yes(Kharif AH)	Yes	Oct	0	Yes	Oct	Yes(Kharif AH)	0	Oct	0	Yes
Nov	Yes(Kharif AH)	YES	Nov	0	Yes	Nov	0	Yes	Nov	Yes(Kharif AH)	0	Nov	Yes(Kharif AH)	YES
Dec	0		Dec	0	0	Dec	Yes(Kharif AH)	0	Dec	0	0	Dec	Yes(Kharif AH)	0

Kharif crops	Rabi Crops	Kharif crops	Rabi Crops	Kharif crops	Rabi Crops	Kharif crops	Rabi Crops	Kharif crops	Rabi Crops
ARKA MILLET	Bengal Gram	JOWER	Groundnet	MIXED	Green Gram	ARECANUT	No Crops	GINGER	pulses
Cotton	Green Gram	Maize	Jowar	VEGETABLES	Groundnet	BANANA			
COWPEA	Groundnet	PADDY	pulses	Harvest period	Jowar	Coffee			
GREENGRAM	Jowar		Vegetables	is 60-120 days	pulses	MANGO			
GROUNDNUT	pulses			after sowing	Vegetables	SUGARCANE			
HORESEGRAM	Vegetables					TAMRIND			
NAVANE									
RAGI (Finger Millet)									
REDGRAM									
SAME LITTLE MILLET									
Various Millets									

To enhance the reliability of the results, the following steps were undertaken:

- Field-level crop residue and FYM data was integrated into the land management files for each farmer to reflect site-specific carbon inputs and enable accurate modelling.
- The model derives IOM for the 0–30 cm of the soil layer. The measured total carbon content for each farmer or field was entered, and a fixed DPM/RPM ratio of 1.44 (suitable for agricultural fields) was applied.
- The year of SOC measurement (e.g., 2018) was specified for each case to ensure temporal alignment.
- The resulting IOM, FYM and crop residue values were validated and incorporated into the final land management configuration files used in model simulations.

$$IOM = 0.049 (\text{total SOC})^{(1.139)}$$

⁵¹

- The model uses average monthly air temperature rate modifying factor *a*, and the factor *a* is computed as follows:

⁵¹ https://www.rothamsted.ac.uk/sites/default/files/Documents/RothC_description.pdf

Where T is the average monthly air temperature.

$$a = \frac{47.91}{1 + e^{\left(\frac{106.06}{T+18.27}\right)}}$$

Table 66: The default decomposition rate constant (k) per year of the active pools is set as follows:

Constant parameter	Compartment or element	Constant values
k	DPM	10
	RPM	0.3
	BIO	0.66
	HUM	0.02

Table 67: The RothC default DPM and RPM ratio for various land cover types.

Land cover type	DPM/RPM
Agricultural/arable/ crops, cultivated land	1.44
Grassland (improved grassland), fallow land	1.44
Forestry (deciduous/tropical woodland, trees), plantation forest	0.25
Semi-natural (unimproved grassland/scrub), weeds, grazing land	0.67
Tree-crop intercropped systems	0.95

Step 7: Model Calibration (baseline 2016-17)

Model calibration is the foremost step to use the RothC model. In RothC model SOC is divided into small amount of inert organic matter (IOM) and other four fractions; decomposable plant material (DPM), resistant plant material (RPM), microbial biomass (BIO) and humified organic matter (HUM). Input data used to run the model are listed. The model is calibrated for both baseline and for practice change.

For baseline calibration total of 397 samples were considered across 3 IPCC zones of Karnataka covering different soil orders using CDM tool. By operating model in forward-mode baseline calibration was done using monitored plant inputs data and FYM (Farmyard manure) data of 2016-17 and climate information (temperature, precipitation, evaporation) for previous five years of the project start date (2012-16). Inert organic matter (IOM) is calculated using the equation (1). depicts the parameters used for baseline calibration.

Step 8: Practice change calibration (2018)

Similarly, For the same batch of samples, practice change calibration has been performed for the year 2018 using weather data, FYM and crop residue of respective year. We conducted a calibration of the RothC model outputs (TOC Modelled) against observed Total Organic Carbon (TOC) measurements for three agro-ecological zones in 2018: Tropical Dry, Tropical Moist, and Tropical Wet. Each plot shows how well the model predicted SOC across those regions.

Table 68 : Model input variables for RothC modelling

Input Category	Parameter	Description / Units	Typical Value / Source for Karnataka
Crop Type	Main Crop	Name of the cultivated crop	Ex:Paddy, Ragi, Redgram, Maize, Sugarcane
Climate Inputs	Monthly Rainfall	mm/month	From IMD station data (district-specific) ⁵²
Climate Inputs	Monthly Temperature	°C/month (mean air temperature)	From IMD ⁵³
Climate Inputs	Evapotranspiration (PET)	mm/month	GEE raster dataset ⁵⁴
Soil Inputs	Clay Content	%	GEE raster dataset ⁵⁵
Soil Inputs	Initial Soil Organic Carbon (SOC)	tC/ha (top 0–30 cm)	ABMS and measured field values
Land Use	Land Use Type	Crop land	Crop land
Management Inputs	FYM Application Rate	tons/ha/year	ABMS and measured field values
Management Inputs	Residue Return to Soil	% of aboveground biomass	ABMS and measured field values
Management Inputs	Cover Crop Inclusion	Yes/No	Yes Both Rabi & Karif Ex:(legumes like cowpea, horse gram)
Carbon Input	Decomposable Plant Material (DPM)	tC/ha/year	Model calculated
Carbon Input	Resistant Plant Material (RPM)	tC/ha/year	Model calculated

⁵² [https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+\(ARC\)/Reports/en](https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+(ARC)/Reports/en)

⁵³ https://empri.karnataka.gov.in/uploads/media_to_upload1691669377.pdf

⁵⁴ https://developers.google.com/earth-engine/datasets/catalog/IDAHO_EPSCOR_TERRACLIMATE

⁵⁵ https://developers.google.com/earth-engine/datasets/catalog/OpenLandMap_SOL_SOL_CLAY-WFRACTION_USDA-3A1A1A_M_v02

Soil Cover	Monthly Soil Cover	Binary (0 = bare, 1 = covered)	Based on the season
Simulation Period	Duration	Number of years simulated	Typically, 30 years

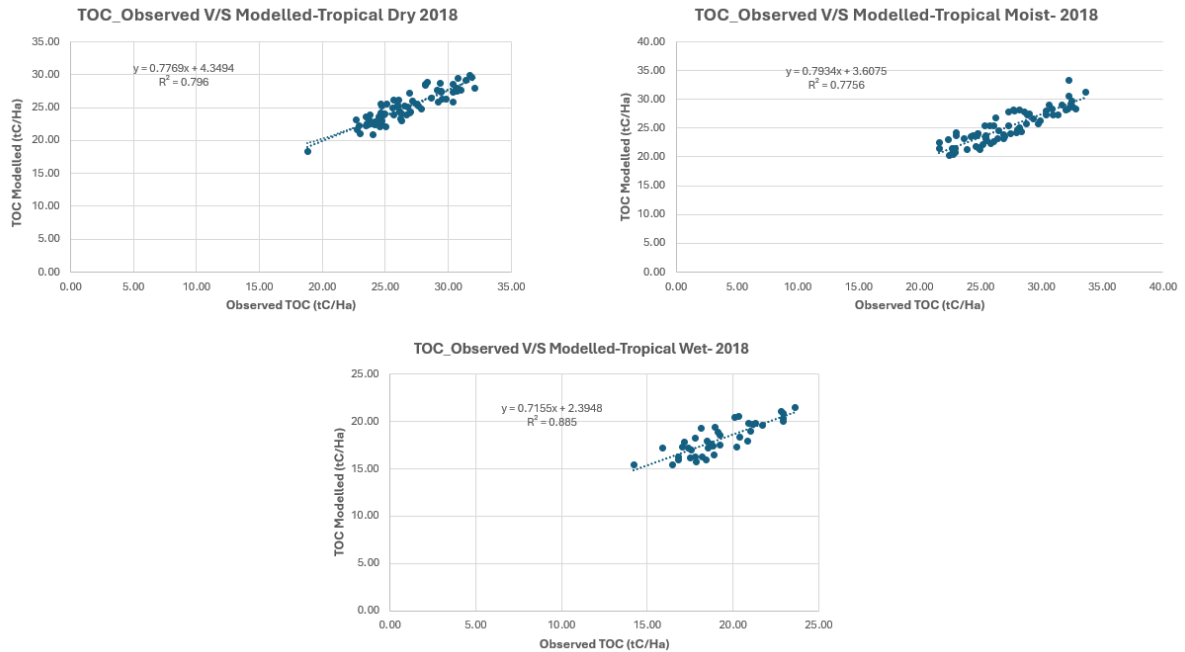


Figure 24: Graph of observed v/s modelled TOC for three IPCC zones (Practice change calibration, 2018)

RothC model performs consistently well across different IPCC zones. The model is suitable for estimating SOC changes,

Step 9: Model Validation (2019 & 2020)

Following calibration, the model utilizes local monthly weather data, laboratory-analysed soil properties, and total carbon inputs to predict soil organic carbon (SOC) stocks.

Management practices along with environmental inputs used in Rothc model play a crucial role in determining carbon inputs and modifying conditions that affect carbon dynamics. These practices are converted into input variables for the model to simulate their impact on SOC. Relevant management factors include:

Table 69 : Model input variables for RothC modelling

Input Category	Parameter	Description / Units	Typical Value / Source for Karnataka
Crop Type	Main Crop	Name of the cultivated crop	Ex:Paddy, Ragi, Redgram, Maize, Sugarcane
Climate Inputs	Monthly Rainfall	mm/month	From IMD station data (district-specific) ⁵⁶
Climate Inputs	Monthly Temperature	°C/month (mean air temperature)	From IMD ⁵⁷
Climate Inputs	Evapotranspiration (PET)	mm/month	GEE raster dataset ⁵⁸
Soil Inputs	Clay Content	%	GEE raster dataset ⁵⁹
Soil Inputs	Initial Soil Organic Carbon (SOC)	tC/ha (top 0–30 cm)	ABMS and measured field values
Land Use	Land Use Type	Crop land	Crop land
Management Inputs	FYM Application Rate	tons/ha/year	ABMS and measured field values
Management Inputs	Residue Return to Soil	% of aboveground biomass	ABMS and measured field values
Management Inputs	Cover Crop Inclusion	Yes/No	Yes Both Rabi & Karif Ex:(legumes like cowpea, horse gram)
Carbon Input	Decomposable Plant Material (DPM)	tC/ha/year	Model calculated
Carbon Input	Resistant Plant Material (RPM)	tC/ha/year	Model calculated
Soil Cover	Monthly Soil Cover	Binary (0 = bare, 1 = covered)	Based on the season

To ensure comprehensive representation across Karnataka, we collected 730 independent soil samples (Batch 2 and Batch 3 samples) within each IPCC climate zone present in the state. The RothC model's reliability was then rigorously tested using an independent dataset of SOC stock data gathered specifically between 2019 and 2020. This forward validation approach allowed us to evaluate the model's accuracy in predicting SOC changes under real-world field conditions. In summary, incorporating this additional validation year:

- Strengthened the model's predictive capacity,

⁵⁶ [https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+\(ARC\)/Reports/en](https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+(ARC)/Reports/en)

⁵⁷ https://empri.karnataka.gov.in/uploads/media_to_upload1691669377.pdf

⁵⁸ https://developers.google.com/earth-engine/datasets/catalog/IDAHO_EPSCOR_TERRACLIMATE

⁵⁹ https://developers.google.com/earth-engine/datasets/catalog/OpenLandMap_SOL_SOL_CLAY-WFRACTION_USDA-3A1A1A_M_v02

- Provided evidence of its robustness under varied field conditions,
- Helped fine-tune assumptions or inputs where necessary.

Goodness of fit measures:

Table 70: Metrics used to measure goodness of fit of RothC model

Metric	Description	Reference	Cut-off
Root Mean Square Error (RMSE)	It is the relative difference between the observed (O) and predicted (P) value (RMSE). The lowest possible value of RMSE is zero, indicating that there is no difference between simulated and observed data.	Smith and Smith, 2007	RMSE/SD < 1
R-squared	The formula in the image is for Pearson's correlation coefficient (r), which measures the strength and direction of the linear relationship between two variables.	Pearson, K. (1895). Note on regression and inheritance in the case of two parents.	R² = 1 → Perfect linear relationship.

Following recommendations regarding model fit made by Singh et al. (2004) the relationship between RMSE and the standard deviation of the data will be evaluated.

Some statistical comparisons between the simulated and measured data based on determination factor (R²), root mean square error (RMSE) were used for model validation (Equations (2) and (3)). The smallest value for RMSE is zero, indicating that there is no difference between measured and simulated values. where O_i and P_i are observed data and the predicted SOC. Suppose that the two correlating variables are b (observed SOC) and c (model simulated SOC), both owing n values b₁, b₂, b₃ and c₁, c₂, c₃..., correspondingly, and then r is defined as follows

$$r = \frac{\sum (b_i - \bar{b})(c_i - \bar{c})}{\sqrt{\sum (b_i - \bar{b})^2 \sum (c_i - \bar{c})^2}} \quad \text{RMSE} = \sqrt{\frac{\sum_{i=1}^n (O_i - P_i)^2}{n}}$$

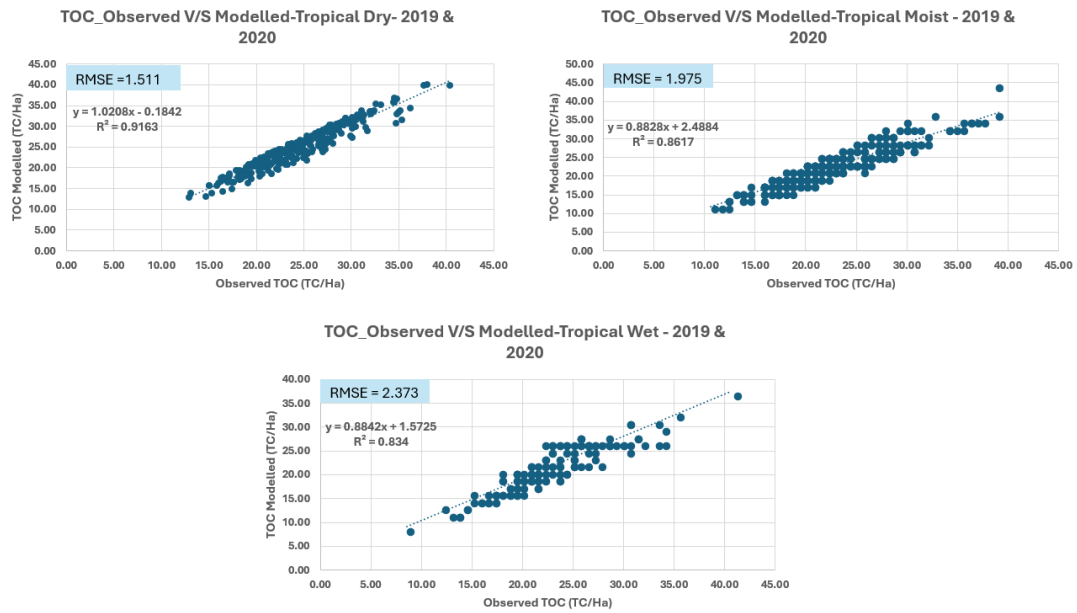


Figure 25: Graph of observed v/s modelled TOC for three IPCC zones (validation, 2019 & 2020)

Table 71: Goodness of fit table for 2019 validation samples

Zone	Equation	R ²	RMSE	Interpretation
Tropical Dry	$y = 1.0208x - 0.1842$	0.9163	1.511	Good fit, model performs well
Tropical Moist	$y = 0.8828x + 2.4884$	0.8617	1.975	Good fit, slight underestimation
Tropical Wet	$y = 0.8842x + 1.5725$	0.834	2.373	Good fit, decent match with observed values

Coefficient of Determination (R²): The value of R²=0.92, 0.86 & 0.83. This indicates that approximately 87.33% of the variation in the modelled TOC values can be explained by the variation in the observed TOC values. This signifies a very strong positive correlation and a good fit of the model to the observed data.

Root Mean Squared Error (RMSE): The value of RMSE=1.511, 1.975 and 2.373 provides a measure of the average magnitude of the errors between the modelled and observed values for 3 IPCC zones as specified in above table. A lower RMSE indicates a better performance of the model. In this case, an RMSE of 1.511 tC/ha suggests that, on average, the model's predictions deviate from the observed values by about 1.511 tonnes of carbon per hectare.

Step 10: Baseline Scenario (2016-2047)

We started by calibrating and validating our model using data from the years 2016 to 2020. This process ensured that our model could accurately represent the real-world Soil Organic Carbon (SOC) dynamics in our study area under different conditions. The graph we previously discussed, comparing observed and modelled TOC for 2019 and 2020, likely played a role in assessing the model's performance during this validation phase Model input data used for baseline scenario(2016-2047) are given in below table,

Table 72: Model input data used for baseline scenario(2016-2047)

Input Category	Parameter	Description / Units	Typical Value / Source for Karnataka
Crop Type	Main Crop	Name of the cultivated crop	Ex:Paddy, Ragi, Redgram, Maize, Sugarcane
Climate Inputs	Monthly Rainfall	mm/month	From IMD station data (district-specific) ⁶⁰
Climate Inputs	Monthly Temperature	°C/month (mean air temperature)	From IMD ⁶¹
Climate Inputs	Evapotranspiration (PET)	mm/month	GEE raster dataset ⁶²
Soil Inputs	Clay Content	%	GEE raster dataset ⁶³
Soil Inputs	Initial Soil Organic Carbon (SOC)	tC/ha (top 0–30 cm)	ABMS and measured field values
Land Use	Land Use Type	Crop land	Crop land
Management Inputs	FYM Application Rate	tons/ha/year	ABMS and measured field values
Management Inputs	Residue Return to Soil	% of aboveground biomass	ABMS and measured field values

⁶⁰ [https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+\(ARC\)/Reports/en](https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+(ARC)/Reports/en)

⁶¹ https://empri.karnataka.gov.in/uploads/media_to_upload1691669377.pdf

⁶² https://developers.google.com/earth-engine/datasets/catalog/IDAHO_EPSCOR_TERRACLIMATE

⁶³ https://developers.google.com/earth-engine/datasets/catalog/OpenLandMap_SOL_SOL_CLAY-WFRACTION_USDA-3A1A1A_M_v02

Management Inputs	Cover Crop Inclusion	Yes/No	Yes Both Rabi & Karif Ex:(legumes like cowpea, horse gram)
Carbon Input	Decomposable Plant Material (DPM)	tC/ha/year	Model calculated
Carbon Input	Resistant Plant Material (RPM)	tC/ha/year	Model calculated
Soil Cover	Monthly Soil Cover	Binary (0 = bare, 1 = covered)	Based on the season

The baseline scenario represents the expected change in Soil Organic Carbon (SOC) in the absence of any practice changes. For this, we used Batch 1 soil samples as the input data.

In this simulation:

- Weather data (2012– 2022) (e.g., temperature, rainfall and evaporation) is varied across the years.
- No project-specific interventions are included – such as crop residue application, organic amendments, or any improved management practices.
- Land use, crop types, and management inputs are kept consistent with pre-project (business-as-usual) conditions.

This allows us to isolate the impact of natural environmental variation (like weather changes) on SOC, serving as a counterfactual reference to compare against the project scenario.



Figure 26 : Baseline scenario for the projection 2017-2047

Step 11: Model application (2018-2047)

Building on this foundation, we proceeded to simulate Soil Organic Carbon (SOC) levels for the year 2022 using the validated model. This was achieved by running the model in forward simulation mode, which allowed us to project future SOC values based on a defined set of input parameters. For this forward simulation, we incorporated detailed weather data, FYM and crop residue inputs corresponding to the years 2018 to 2022, which aligns with the timeline of the practice change.

During this period, crop residue and FYM application was implemented as a sustainable practice, and the timing of its application varied based on the specific intervention start date for each individual farmer. These inputs were carefully tailored for each of the 397 batch-1 sample locations, which were previously used in the initial model calibration and baseline SOC estimation. Using the same locations ensured consistency in evaluating the impact of the intervention over time.

Table 73: Model input data used for model application (2018-2047)

Input Category	Parameter	Description / Units	Typical Value / Source for Karnataka
Crop Type	Main Crop	Name of the cultivated crop	Ex:Paddy, Ragi, Redgram, Maize, Sugarcane
Climate Inputs	Monthly Rainfall	mm/month	From IMD station data (district-specific) ⁶⁴
Climate Inputs	Monthly Temperature	°C/month (mean air temperature)	From IMD ⁶⁵
Climate Inputs	Evapotranspiration (PET)	mm/month	GEE raster dataset ⁶⁶
Soil Inputs	Clay Content	%	GEE raster dataset ⁶⁷
Soil Inputs	Initial Soil Organic Carbon (SOC)	tC/ha (top 0–30 cm)	ABMS and measured field values
Land Use	Land Use Type	Crop land	Crop land
Management Inputs	FYM Application Rate	tons/ha/year	ABMS and measured field values
Management Inputs	Residue Return to Soil	% of aboveground biomass	ABMS and measured field values
Management Inputs	Cover Crop Inclusion	Yes/No	Yes Both Rabi & Karif Ex:(legumes like cowpea, horse gram)

⁶⁴ [https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+\(ARC\)/Reports/en](https://des.karnataka.gov.in/info-2/Agricultural+Census++Rainfall+and+Sample+check+on+Developmental+Programmes+(ARC)/Reports/en)

⁶⁵ https://empri.karnataka.gov.in/uploads/media_to_upload1691669377.pdf

⁶⁶ https://developers.google.com/earth-engine/datasets/catalog/IDAHO_EPSCOR_TERRACLIMATE

⁶⁷ https://developers.google.com/earth-engine/datasets/catalog/OpenLandMap_SOL_SOL_CLAY-WFRACTION_USDA-3A1A1A_M_v02

Carbon Input	Decomposable Plant Material (DPM)	tC/ha/year	Model calculated
Carbon Input	Resistant Plant Material (RPM)	tC/ha/year	Model calculated
Soil Cover	Monthly Soil Cover	Binary (0 = bare, 1 = covered)	Based on the season

The simulation under the project scenario aimed to capture the changes in Total Organic Carbon (TOC) within the soil, directly reflecting the impact of sustainable agricultural practices—such as the application of FYM and crop residues—adopted during the implementation phase. By comparing these projections with baseline values, we were able to estimate the net change in SOC attributable to project activities, thereby assessing the effectiveness of the intervention in enhancing soil carbon sequestration.

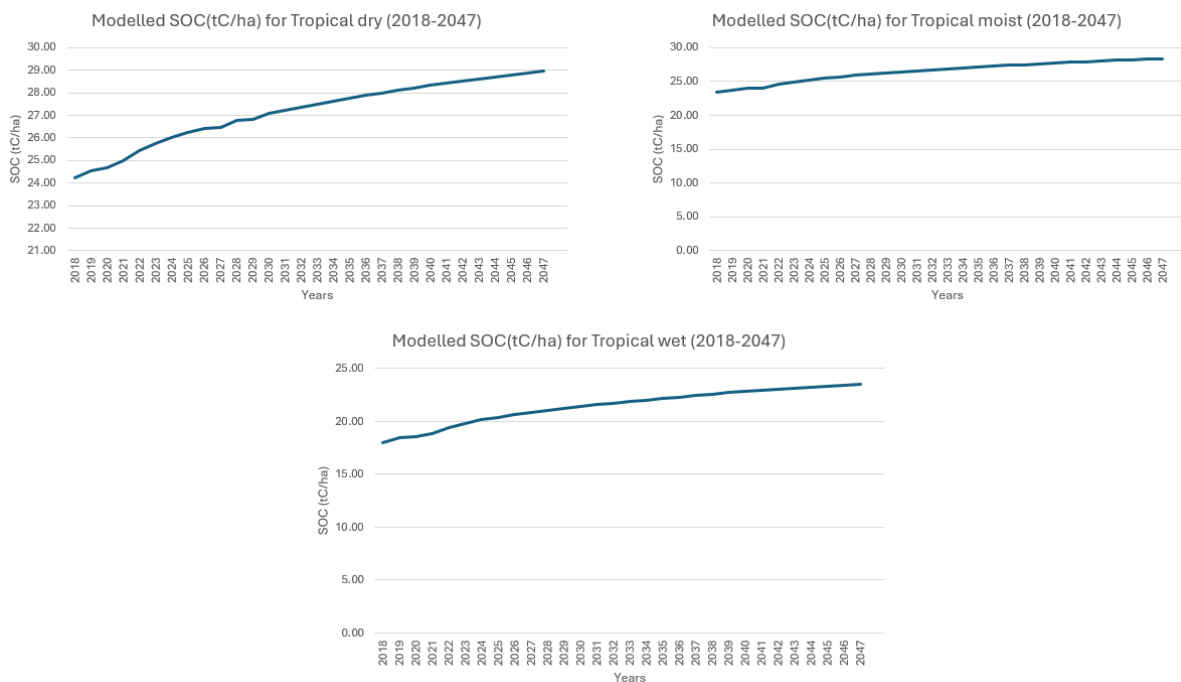


Figure 27 : Project scenario for the projection 2017-2047

The deviation of modelled SOC from measure SOC for the year 2022 is calculated using equation (2). The deviation is <15% in all three IPCC zones.

$$\text{Deviation (\%)} = [100 * (\text{measured} - \text{modelled}) / \text{measured}] \quad \text{Equation 1}$$

Table 74: Deviation of modelled SOC from measure SOC for the year 2022

IPCC zone	Measured SOC (2022) tC/ha	Modelled S OC (2022) tC/ha	Deviation (%)
Tropical dry	27.85	25.43	-8.7

Tropical moist	28.39	24.55	-13.5
Tropical wet	20.49	19.43	-13.6

The difference in the SOC between the baseline period 2022 and the project scenario 2022 was considered for quantification of the soil organic carbon for this monitoring period using the approach specific in VM0017.

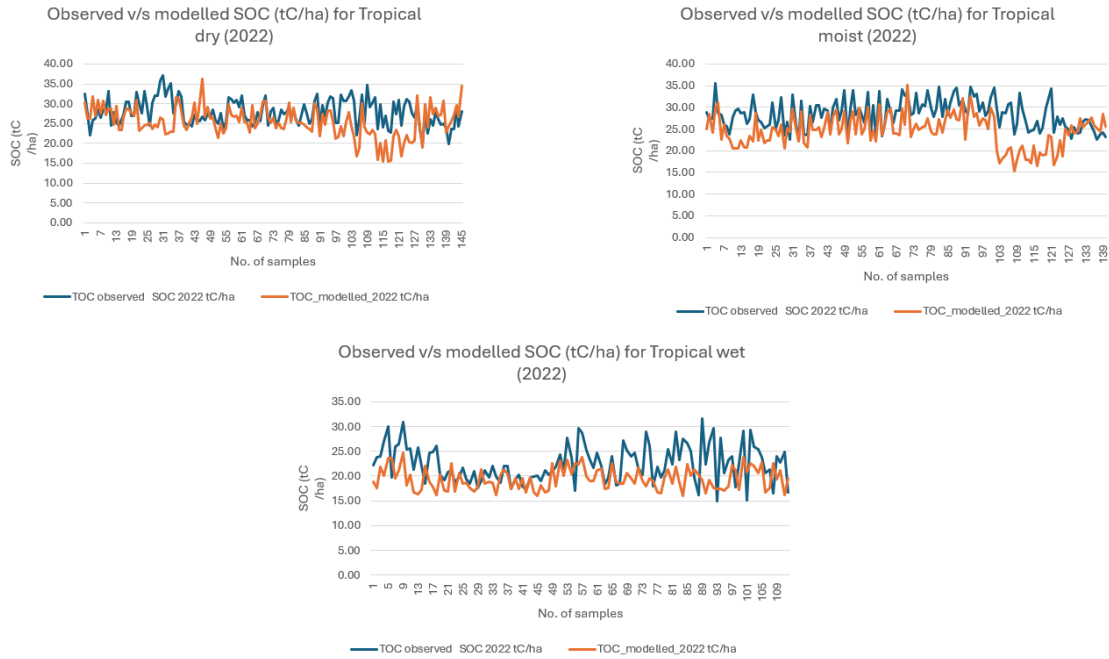


Figure 28 : Observed v/s modelled SOC (tC/ha) across 3 IPCC zones for the year 2022

Step 12: Creating a RothC model scenario

Figure 29 : Creating scenario by using weather file, land management file and IOM value

Figure 30: Creating scenario by specifying start year and number of years of prediction

Defining Output and Input Files:

- We are first required to specify an **output file name**. This is where the results of the model simulation (e.g., the predicted SOC values for each time step and location) will be saved.

- We also need to provide a **site name**. This likely serves as an identifier for the specific simulation or the geographical area being modelled.
- Crucially, we need to specify a **land management file name**. This file contains detailed information about the land use practices, agricultural interventions (which could be the "project activities"), and other management practices being implemented.

Accessing Existing Files:

- The system provides a user-friendly way to select existing weather and land management files. By clicking the command buttons next to "site name" or "land management file name," we can access a list of files already stored in the system. This prevents us from having to manually remember or type out the exact file names.

Reviewing File Information:

- The ability to view the information within these files by clicking in the corresponding text box is a valuable step. This allows us to verify that we have selected the correct weather data (e.g., for the year 2022 as in our application) and the appropriate land management scenarios that represent the project activities we want to evaluate. The "Quit" or <alt q> option allows us to close the viewer once we've confirmed the file contents.

Setting Simulation Parameters:

- We need to decide whether to run the model in **short term or equilibrium mode**.
 - **Short term mode** would likely simulate the SOC changes over a specific period (e.g., the 2016-2022 timeframe we've been discussing).
 - **Equilibrium mode**, as the example suggests, would run the model until the SOC levels reach a steady state under the given environmental and management conditions. This helps understand the long-term potential impact of those conditions.
- We also need to input the IOM (Inert Organic Matter) content of the soil. IOM is a relatively stable fraction of soil organic matter that changes very slowly. This is an important initial condition for the model.
- Finally, we need to provide the DPM/RPM (Decomposable Plant Material to Resistant Plant Material) ratio. This parameter describes the relative proportions of different types of plant residues entering the soil, which have different decomposition rates and thus influence SOC dynamics.

Running to Equilibrium:

- The example provided indicates that a specific set of these inputs will run the model to equilibrium. This suggests that for certain long-term analyses, we are interested in seeing the eventual stable SOC levels under a particular scenario.

To run the model - Highlight the Run model menu and click Carbon Model (RothC26-3).

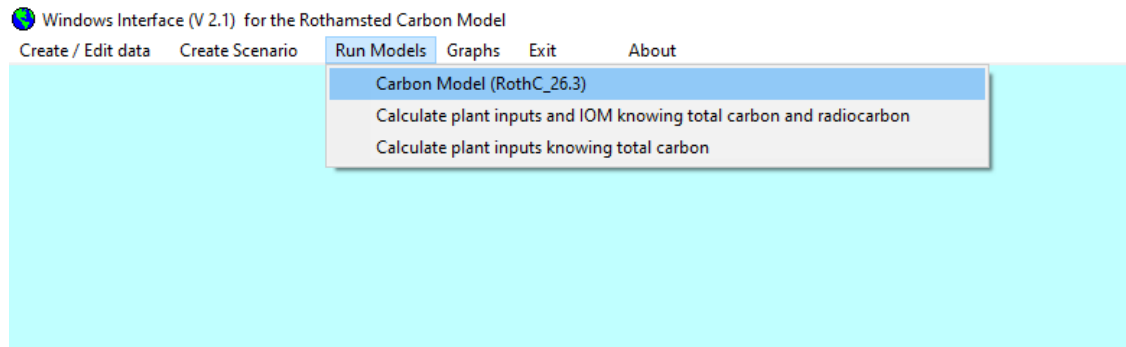


Figure 31: Run the model by selecting Carbon Model option

When the model has finished the message below will appear.

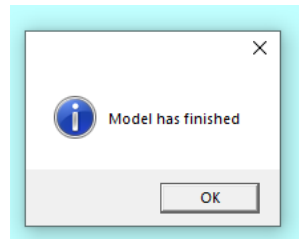


Figure 32: Successful completion of RothC model

Conclusion

The implementation of the RothC model for simulating Soil Organic Carbon (SOC) dynamics across Karnataka has proven to be both robust and reliable. Through meticulous calibration using field-derived soil parameters (such as clay content, bulk density, and SOC levels), climate data from government and satellite sources, and detailed management practice records, the model was tailored to represent local conditions across the three IPCC climate zones in the state—Tropical Wet, Tropical Dry, and Tropical Moist.

Validation using independent datasets from the years 2019 and 2020 confirmed the model’s accuracy, with excellent alignment between observed and modelled SOC values. Indicating a strong goodness of fit and minimal deviation from field-observed values. This validation process added a critical layer of confidence in the model’s predictive capability.

Beyond historical analysis, the RothC model was successfully applied to project SOC stocks under various climate change and management intervention scenarios. Its dynamic structure allowed for the integration of future temperature, precipitation, and potential evapotranspiration data, thus enabling scenario-based forecasting. This makes it an invaluable decision-support tool for policymakers and land managers aiming to improve soil health, enhance carbon sequestration, and build climate-resilient agricultural systems.

In summary, the RothC model effectively captured the complex interactions between soil properties, climatic variables, and land management practices. Its successful application across diverse IPCC zones in Karnataka establishes its utility as a scientifically credible tool for long-term environmental monitoring and climate change impact assessments related to soil carbon dynamics.

APPENDIX 2

Socio-economic analysis of small holding farmers in the project area

IPCC Zone	Landholding			Education							Home		
	< 5 acres	5-10 acres	>10 acres	Illiterate	Primary school	Middle school	High school	College	Degree	Post-graduate	Hut	Kachha house	Pakka house
Tropical dry	16,059	6,333	457	-	6,905	10,198	3,562	1,939	228	2	-	3,427	19,422
Tropical moist	6,495	2,676	230	-	3,102	3,760	2,162	188	94	-	-	1,410	7,991
Tropical wet	186	73	5	-	84	112	52	13	3	1	-	40	225

IPCC Zone	Occupation		Caste			Farm power:			Family	
	Agriculture	Non agriculture	SC/ST	OBC	Others	Draught animals	Power tiller	Tractor for land preparation	Size: Up to 5	More than 5
Tropical dry	22849	0	3427	14852	4570	17109	46	0	21021	1828
Tropical moist	9401	0	1410	6111	1880	6262	19	0	8649	752
Tropical wet	265	0	40	172	53	167	1	0	244	21

IPCC Zone	Agricultural implements					Material possession				
	Wooden plough	M.B. Plough	Seed cum fertilizer drill	Organic Pesticide Sprayer	Bullock cart	Bicycle	Radio	Motorcycle	Television	Car
Tropical dry	21,707	457	685	9,140	7,997	21,707	12,567	4,570	21,021	685
Tropical moist	8,722	188	282	3,760	3,290	8,931	5,171	1,880	8,649	282
Tropical wet	252	5	8	106	93	252	146	53	244	8

APPENDIX 3

Comparison table on similar projects in Karnataka implementing SALM practices to establish common practice

ORGANIC GROUPS/COMPANIES IN KARNATAKA								Best Organic Practices Adopted				Website link
Sl. No.	Name of the Organic Company/Groups)	Total Ha	Project start date	Nature of venture and revenue	Adoption of best practices	Term of the contract with farmers	Targeted Crops	Use of Organic fertilizer	Crop residue used for mulching	Stop Burning Trash	Agroforestry	
3115 VERRA project	VGS	55,000	Oct-17	Developed as VERRA project based on the sale of carbon credits	sustainable agricultural practices such as use of organic fertilizer,	For 30-year period based on meeting specific requirements related to VERRA project implementation	More than 20 types of crops such as pulses, paddy, millets, vegetables	yes	yes	NA	yes	www.vgsind.com/projects
1	Gopalan Organics	120 acres	2000	Commercial based on supply and demand market factors	The vegetables are grown in a clean, sterile environment, with zero pesticides. As compared to conventional farming methods, the setup consumes up	companies often enter into contractual agreements with farmer groups to ensure a consistent supply of specific produce or products. This practice, commonly known as	Fruits & Vegetables	Yes	Yes	NA	NO	https://www.gopalanorganics.com/gopalan-organic-who-we-are.php

					<p>to 80 percent less water to grow the produce due to “recirculating irrigation system</p>	<p>contract farming, is driven by several factors, including:</p> <p>Market Demand: Companies need a reliable source of raw materials to meet the demands of both domestic and export markets.</p> <p>Quality Control: Contract farming allows companies to specify the quality standards and production methods that must be followed by farmers, ensuring that the final product meets their requirements.</p> <p>Cost Efficiency: By contracting</p>						
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						with farmers, companies can often negotiate favorable terms and secure a steady supply of produce at competitive prices.						
2	Phalada Agro	10,000 acres	2002	Commercial based on supply and demand market factors	usage of less pesticides	Contract farming (same as above)	Various Produce	Yes	Yes	Yes	NO	http://phaladaagro.com/farmers/
3	24 Mantra Organics	more than 20,000 acres	2004	Commercial based on supply and demand market factors	consumes up to 80 percent less water to grow the produce due to	Contract farming (same as above)	Various Produce	Yes	No	Yes	NO	https://www.24mantra.com/24-mantra-organic-our-organic-farmers/
4	Sahaja Sambrudha	37,000 acres	2001	Commercial based on supply and demand market factors	Organic inputs for farming	Contract farming (same as above)	rice, finger millet, minor millet, pulses, vegetables, tubers,	Yes	Yes	Yes	NO	https://www.sahajasamrudha.org/sustainable-agriculture/

APPENDIX 4

SALM activities project stakeholder consulting and training photographs with farmers















