CSA calculator Manual: Assessing climate-smartness of technical options at farm level

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The overall purpose of CCAFS is to marshal the science and expertise of CGIAR and partners to catalyze positive change towards climate-smart agriculture (CSA), food systems and landscapes, and position CGIAR to play a major role in bringing to scale practices, technologies and institutions that enable agriculture to meet triple goals of food security, adaptation and mitigation.

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The design, piloting and implementation of the CSA Monitoring framework reflects a collaborative effort between CCAFS FP2, the Alliance Bioversity International and CIAT, CIRAD and the wide range of CCAFS regional leaders and CSV-implementing partners across Latin America, West and East Africa, and South Asia who provided operational support on the ground as well as insightful feedbacks during the piloting/ testing (2017 and 2018) and rolling out (2019-2020) period. They include in East Africa: The International Livestock Research Institute (ILRI), the Savanna Agricultural Research Institute (CSIR-SARI) the Technology Promotion and Outreach Research Programme, National Agricultural Research Organisation (NARO) and InterAid; in West Africa: World Agroforestry Centre (ICRAF), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and l'Institut Sénégalais de Recherches Agricoles (ISRA); In Latin America: Fundación Ecohabitat and Centro Agronómico Tropical de Investigación y Enseñanza (CATIE); La Asociación Regional Campesina Ch'orti' (ASORECH) and Comisión de Acción Social Menonita (CASM);in South Asia the International Maize and Wheat Improvement Center (CIMMYT); World Fish and Local Initiatives for Biodiversity, Research and Development (Li-Bird). We extend our sincere appreciation to each and all of them, as well as to the CSV communities that welcomed us and allowed us to carry out this work

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Abstract

The CSA-Farm Calculator tool was developed as part of the CSA Multilevel Monitoring Framework implemented in the context of the Learning Platform Participatory evaluation of Climate-Smart Agricultural (CSA) practices and technologies across the AR4D Climate-Smart Villages (CSVs) network. It builds on a farm model included in the GeoFarmer app allowing the prospective assessment of farm performance in response to the implementation of different CSA practices/packages and other farming management activities in terms of productivity, adaptive capacity, and mitigation potential (in other words the “climate-smartness” of the farm) and specifically looking at synergies and trade-offs.

Content

Glossary

CSA

Climate-smart agriculture (CSA) is an integrative approach to address these interlinked challenges of food security and climate change, that explicitly aims for three objectives (or pillars): i) Sustainably increasing agricultural productivity, to support equitable increases in farm incomes, food security and development; ii) Adapting and building resilience of agricultural and food security systems to climate change at multiple levels; and iii) Reducing greenhouse gas emissions from agriculture (including crops, livestock and fisheries).

CSA practice

Adopting a synergistic view of the three CSA pillars (productivity; adaptation/ resilience; and mitigation) facilitates improved distinction of CSA from other conventional agricultural production systems. Consequently, any agronomic practice that addresses at least two of the three pillars can be part of CSA. For example, intercropping can have a positive effect on the three pillars of CSA by encouraging food diversification, more stable yields, and a likely decrease in greenhouse gas emissions related to the reduced use of mineral nitrogen fertilizer. This flexible way of defining CSA allows context-specific identification of CSA options according to national and local specificities and priorities.

Farm

Any farm can take a diversity of configurations. A uniform definition across all case studies is unlikely to be useful. Hence each case study will need to use definitions of a 'farm' that are relevant to their context. However, at this scale, emphasis is made on the production system that can be defined as the way the farmer and his or her family allocate their resources to produce crop and livestock/fish goods.

Introduction

The economic lives of smallholder farmers in emerging and developing countries rely on agriculture and ecosystem services, thus, their livelihoods are exposed to climate variations. In fact, they are highly vulnerable to climate change. Since 2010, the Research Program on Climate Change, Agriculture and Food Security (CCAFS) is implementing Climate-Smart Villages (CSV), an AR4D participatory approach to scale up climate-smart agriculture (CSA) (CCAFS. 2016) with farming communities in South Asia, Sub-Saharan Africa, South-East Asia, and Latin America. The approach uses participatory research for implementation of sustainable farming practices that are adapted to climate change, and the use of participatory methods to foster the use of climate services to improve farmers decision making to prepare for climate variability and climate change.

In its second Phase, and as part of the CCAFS Learning Platform (LP2), participatory evaluation of Climate-Smart Agricultural (CSA) practices and technologies across the AR4D Climate-Smart Villages (CSVs) network, CCAFS Flagship 2 developed the Integrated CSA Monitoring Framework. This framework supports a global, systemic, and standardized effort to build context-specific evidence on:

- Adoption trends and drivers associated with the implementation of CSA practices and technologies; and Access and use of climate information services (CIS)
- Gender-disaggregated (perceived) effects of the implementation of CSA practices on household level income, productivity, food security, adaptive capacity, and gender dimensions
- Effects of CSA practices and technologies on farm-level performance (in terms of the three CSA pillars: productivity, climate resilience/ adaptation, and climate-effects mitigation)

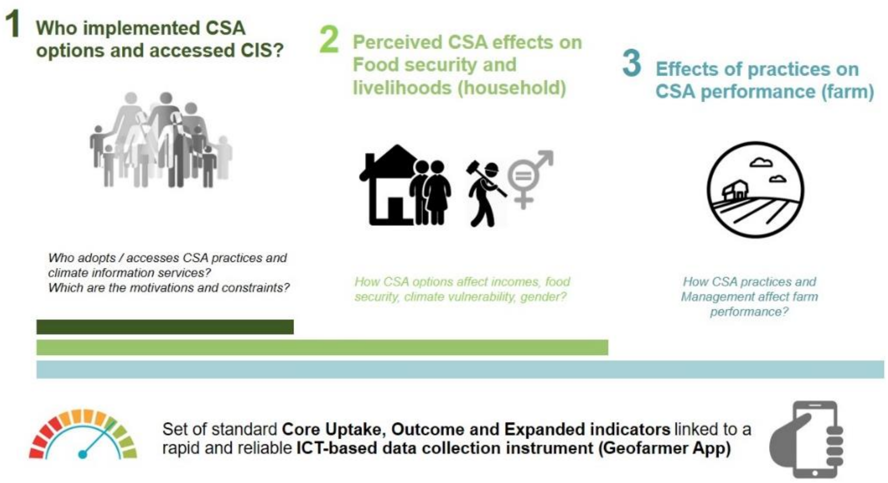

Figure 1. CSA indicators are measured across three levels.

Overall, it aims to better understand the extent to which farmers' implementation of CSA options might lead to positive socio-economic and biophysical changes. The key research questions addressed include:

1. Within each CSV site, who adopts which CSA technologies and practices and what are their motivations or constraining factors? To what extent do farmers access and use climate information services?
2. What are the gender-disaggregated perceived effects of implementing CSA options on farmers' livelihoods (agricultural production, income, food and nutrition security, dietary diversity and adaptive capacity). This will include effects on key gender dimensions (participation in decision-making, participation in CSA implementation and dis-adoption, control and access over resources and labor)?
3. What are the CSA performance levels, synergies and trade-offs found at farm level? (Whole-farm model analysis).

This manual focuses on the **CSA-Farm Calculator tool** developed to specifically tackle the third question.

The CSA-farm calculator

The CSA-Farm Calculator tool builds on a farm model that has been included in the GeoFarmer app (see page 6) as worksheet-module (Eitzinger et al., 2019, 2020), allowing the prospective assessment of farm performance across the three CSA pillars, with special attention to the trade-offs and synergies among them and in response to the implementation of different CSA practices and other farming management activities.

The CSA calculator allows determining how the implementation of different packages or combinations of CSA practices or technologies linked with any specific farming management approach affects the farm performance in terms of productivity, adaptive capacity, and mitigation potential (in other words the "climate-smartness" of the farm).

After a presentation of the rationale for the CSA calculator, we present its 7 core indicators, the main calculations, and its implementation mode.

Justification

The introduction of a new practice at farm level implies specific reframing of existing production systems and activities (Andrieu et al., 2015). Whole-farm models are particularly relevant for analyzing such reframing since they can be used to represent the links between farm sub-systems and decisions taken by the farmer (Whitbread et al., 2010). Rodriguez et al. (2014) showed that whole-farm models are useful tools for ex-ante evaluations of options and identifying farming system characteristics that may increase resilience in the face of change and uncertainty. This scale of assessment is also the most appropriate to assess synergies and trade-offs in portfolios of practices. Some whole-farm models have been developed to analyze the effect of different strategies at the farm level to cope with climate change (Claessens et al., 2012; Rodriguez et al., 2014). Recently, Hammond et al. (2017) developed the Rural Household Multi-Indicator Survey (RHoMIS) for rapid characterization of households to inform climate-smart agriculture interventions using quantitative indicators (income, emissions intensity, food availability) and qualitative indicators (poverty index, gender-equity index, household dietary diversity).

CSA Multilevel Monitoring Framework

To quantitatively assess the climate-smartness of a farm, the CSA Monitoring Framework suggests a minimal set of seven indicators associated with the three CSA pillars linked to farm resource (fodder, food, nutrient, water, cash) analysis (Bonilla-Findji et al., 2021).

These core indicators are also used to determine the synergies and trade-offs between the three pillars (productivity/food security-resilience and mitigation). They are calculated in a survey module called "farm calculator" based on sub-indicators calculated in "crop" and "animal modules".

7 CORE CSA *OUTCOME* INDICATORS		
Productivity/ Food security	**Adaptation/ Resilience**	**Mitigation**
[CP.1] Caloric ratio of the farm (%)	[C.A1] Biodiversity index (%)	[C.M1] Emission / Sequestration of CO_2
[CP.2] Fodder ratio of the farm (%)	[C.A2] Water balance (%)	
[CP.3] Cost/Benefit ratio (%)	[C.A3] Nutrient balance (%)	

In the CSA literature, **productivity** is often assessed qualitatively (scores) or quantitatively in terms of yield, labor, income, and food security in some of its diverse dimensions (food access, availability, utilization, stability) (Richardson, 2010). In the CSA calculator we used three indicators: **caloric self-sufficiency** as a proxy for food utilization, **cost: benefit ratio of the farm** as a proxy of both food economic access and income, and **fodder ratio** to assess the balance between fodder production and fodder demand (Osorio et al., 2019).

The second pillar is probably the most challenging, which is generally assessed in terms of improved resilience, including various dimensions such as socioeconomic, ecological, or engineering resilience (Antwi et al., 2014). Acosta-Alba et al. (2019) proposed evaluating ecological resilience using life-cycle assessment. In the CSA calculator we focused on engineering resilience that is more specifically related to the reorganization capacity of farm production factors (e.g., soil, water, crops) and calculated the **water and nutrient self-sufficiencies** of the farm. Such indicators were used to detect imbalances between supply and demand in farm production factors that can lead to a depletion of environmental resources (Sempore et al., 2016; Van den Bosch et al., 1998). We also considered in this assessment of engineering resilience the planned **biodiversity** that is the biodiversity associated with the crops and livestock purposely included in the agroecosystem by the farmer, and which will vary depending on the management of inputs and crop spatial/temporal arrangements (Altieri 1999). We used the index proposed by Gobbi and Casasola (2003) that ranked this biodiversity between 0 and 1 according to the type of land use.

To assess the **mitigation potential** (carbon emissions and sequestration capacity), we use the Tiers 1. Tier 1 employs the gain-loss method described in the IPCC Guidelines and the default emission factors and other parameters provided by the IPCC.

Structure of the CSA Calculator

The CSA calculator is made-up three main modules:

1. **Farm module** that includes the general data and metrics of the farm, such as the composition of the family or the total area of the farm, and the seven core indicators that compile the data collected in the crop and animal modules
2. **Crop module** that describes the specific management and production of any crop cultivated in the previous year. The same number of modules needs to be replicated as the number of cultivated crops on the farm
3. **Animal module**, that describes the specific management and production of a given livestock system. The same number of modules needs to be replicated as the number of livestock systems on the farm

Farm module

This is the module where the general structural data of the farm (e.g., family composition, total area of the farm, total grazing area of the farm) and the data on the main crops of the home-garden are collected (Appendix 1).

These data are then used for the automated calculation of three sub-indicators:

i) Caloric needs of the family (equation 1)
ii) Supply of calories by the home-garden (equation 2)
iii) Benefit generated by the home-garden (equation 3)

$$Caloric\ needs\ of\ the\ family = \sum Caloric\ need\ per\ age\ category \times number\ of\ family\ member\ in\ this\ category \quad \text{Eq.1}$$

$$Supply\ of\ calories\ by\ the\ homegarden = \sum Self\ consumed\ homegarden\ crop \times caloric\ value\ of\ the\ crop \quad \text{Eq.2}$$

$$Benefit\ generated\ by\ the\ homegarden = \sum Sold\ homegarden\ crop \times sale\ price\ of\ the\ crop \quad \text{Eq.3}$$

These three sub-indicators, also with sub-indicators calculated in the crop and animal modules will feed the calculation of the seven core indicators:

iv) Caloric ratio of the farm (equation 4)
v) Fodder ratio of the farm (equation 5)
vi) Cost benefit ratio of the farm (equation 6)
vii) Biodiversity index (equation 7)
viii) Water balance (equation 8)
ix) Nutrient balance (equation 9)
x) Emissions (equation 10)

$Caloric\ ratio\ of\ the\ farm = \sum Caloric\ crop\ supply \div Caloric\ needs\ of\ the\ family\ \times\ 100$ Eq.4

Fodder ratio of the farm$= \Sigma$ crop fodder supply$\div \Sigma$ animal fodder demand$\times$ 100〗 Eq.5

$\frac{Cost}{Benefit} ratio = [(\sum crop\ benefit + \sum animal\ benefit) \div (\Sigma\ crop\ cost +\ \Sigma\ animal\ cost)] \times\ 100$ Eq.6

A Gini-Simpson index of diversity is then calculated, both for crops and animals:

$Biodiversity\ index = 1\ -\ \mathrm{D}\ =\ 1 - \ \Sigma\,\mathrm{pi2}$ Eq.7

in which pi is the abundance and i the proportion of individuals found in the i-th species

$Water\ balance = \sum crop\ water\ supply\ \div\ \ \Sigma\ crop\ water\ demand \times 100$ Eq.8

$Nutrient\ balance = \sum crop\ nutrient\ supply \div crop\ nutrient\ demand\ \ \times 100$ Eq.9

$Emissions\ of\ CO2 = [(\sum CO2\ crop\ emissions + \sum CO2\ animal\ emissions)$ Eq.10

The crop fodder supply; crop cost: benefit; crop nutrient supply and demand; and crop emissions are calculated in the crop module.

The animal fodder demand; animal cost: benefit; and animal CO_2 emissions are calculated in the animal module.

Crop module

This module describes crop management and production. It needs to be replicated to consider each of the main crops grown in the farm; particularly those where the CSA options are applied. The management described is the main management applied for that crop. However, if for a given crop, contrasted managements are applied, the user may decide to distinguish these managements and create a new crop module for each separate management regime.

In this module, 46 data (Appendix 2) are collected during the survey with the farmer (area of the crop, fertility management, management costs, amount self-consumed and sold). These data are used for the calculation of six sub-indicators:

1. Supplies of calories by the crop (equation 11)
2. Fodder supply of the crop (equation 12)
3. Cost of the crop (equation 13)
4. Benefit of the crop (equation 14)
5. Nitrogen supply by the crop (equation 15)
6. CO_2 emissions by the crop management (equation 16)

$Supplies\ of\ calories\ by\ the\ crop =\ Amount\ self - consumed\ crop\ \times\ caloric\ value\ of\ the\ crop$ Eq. 11

$Fodder\ supply\ of\ the\ crop =\ Production\ of\ the\ crop\ x\ harvested\ Index\ \times\ fodder\ value$ Eq. 12

$Cost\ of\ the\ crop = Purchase\ price\ of\ seed \times Amount\ of\ purchased\ seed +\ Tillage\ cost + Weeding\ cost + Harvesting\ cost$ Eq. 13

$Benefit\ of\ the\ crop =\ Amount\ sold \times\ Sale\ price$ Eq.14

$Nitrogen\ supply\ by\ the\ crop = Nitrogen\ supply\ by\ organic\ fertilizers + Nitrogen\ supply\ by\ mineral\ fertilizers + Nitrogen\ suppy\ by\ crop\ residues$ Eq.15

Crop emissions $= Direct\ emissions + Indirect\ emissions$ Eq.16

Animal module

This module describes the management and production of the livestock system. It needs to be individually replicated to consider each of the main livestock systems existing on the farm (e.g., cattle, pig, poultry, etc.) particularly those where the CSA options are applied. The management described in the module is the main management applied for that livestock system. However, if for a given livestock type contrasted managements are applied, the user may decide to distinguish these managements and to create a new module.

In this module, juvenile animals, productive animals, and non-productive animals are differentiated. A total of 42 data (Appendix 3) are collected during the survey with the farmer (e.g., number of animals per category, sales and purchases, feeding management, manure management). They are used for the automated calculation of five sub-indicators:

- Supplies of calories by the livestock systems (equation 17)
- Fodder demand of the livestock system (equation 18)
- Cost of the livestock systems (equation 19)
- Benefit of the livestock system (equation 20)
- CO_2 equivalent emissions by the livestock system management (equation 21)

$$Supply\ of\ calories\ by\ the\ livestock\ system = Amount\ of\ meat\ self\ consumed \times caloric\ value\ of\ meat + amount\ of\ milk\ self\ consumed + caloric\ value\ of\ milk$$ Eq.17

$$Fodder\ demand\ of\ the\ livestock\ systems = Number\ of\ animals\ per\ category \times fodder\ demand\ of\ one\ animal$$ Eq.18

$$Cost\ of\ the\ livestock\ system = Purchase\ price \times number\ of\ animal\ purchased$$ Eq.19

$$Benefit\ of\ the\ livestock\ system = sale\ price \times number\ of\ animals\ sold$$ Eq.20

$$C02\ equivalent\ emissions\ by\ the\ livestock\ system = Methane\ enteric\ emissions + Methane\ and\ N20\ manure\ management\ emissions + Direct\ and\ Indirect\ Dung\ and\ Urine\ while\ grazing\ emissions$$ Eq.21

Sampling size

Select among the list of CSA-adopting Households of the study site, **8 to 10 HH that implement each of the prioritized practices or "packages of CSA practices"**. For example, if you prioritized four practices in your site then you will need between 32 and 40 farmers completing the Calculator Modules.

Respondent selection

The main respondent must be a person in the household **who knows about farming practices** on the household farm. Therefore, it may not be the “head of household” or “farm head” as this concept does not reflect decision-making or knowledge of farming practices in many parts of the world.

Guidelines for enumerators

The enumerators need to be experienced and qualified in the following:

- Data collection through quantitative questionnaires and ICT tools
- Engaging farmers in open-ended semi-structured questionnaires, including listening, processing, and probing for more detailed answers
- Be subject matter specialists with good knowledge of the CSA practices promoted in the site, local farming systems, crop and livestock management or livelihoods (including familiarity with local practices, units used by the farmers etc.)
- Speaking the local language

Contact and permission

When contacting and requesting collaboration be sure to first read/complete the On-line Informed Consent (Appendix 4):

- Explain that the information will contribute to a continent-wide research project that aims to influence policy, and improve wellbeing, especially for the poor.
- Explain that all information collected is anonymous and answers given will not be attributed to individuals.
- Explain that answers given will have no consequences for the respondent.
- Describe how reports based on the information will be made available, and how respondents may also benefit.

Conducting interviews

The data collection is a structured interview with a detailed questionnaire and hence should be conducted by a researcher familiar with the method and able to work in the language of the respondent when possible. The interviewer should understand and use good practices for this type of activity including things such as:

- Selecting a comfortable and private place for the interview
- Introducing themselves and the project
- Explaining the purpose and conditions of the data collection
- Obtaining consent

GeoFarmer Smart-App for data collection

GeoFarmer was conceptualized as a tool that enables a multi-way communication channel between farmers and researchers and among groups of farmers, allowing community workers and smallholders to easily collect and share information during project interventions (Eitzinger et al., 2019, 2020).

GeoFarmer functionalities allow creating worksheets for data collection for the whole CSA Monitoring Framework and for the calculation of the standard indicators at household and at farm level.

Based on a principle of simplicity in structure and design, a set of thematic survey-modules were created in GeoFarmer (Eitzinger et al. 2019) and published in different Climate-Smart Villages channels.

For the farm-level assessments (CSA Calculator), worksheets for data collection were developed and published via the same channels. The farm-level assessment included three types of worksheets: the *Farm Calculator, Animal Calculator and Crop calculator worksheets (for most relevant animal types and crops, respectively).*

GeoFarmer worksheets allow for collecting primary data as variables, but also another functionality allows using formulas with common mathematical operations to define the calculation of indicators by using the collected primary variable data. After collecting all primary data variables at farm level, both, variables, and calculated indicators, are available in the worksheets

Local facilitators used GeoFarmer to carry out interviews with farmers and fill those “CSA calculator” survey modules (see example in Figure 2).

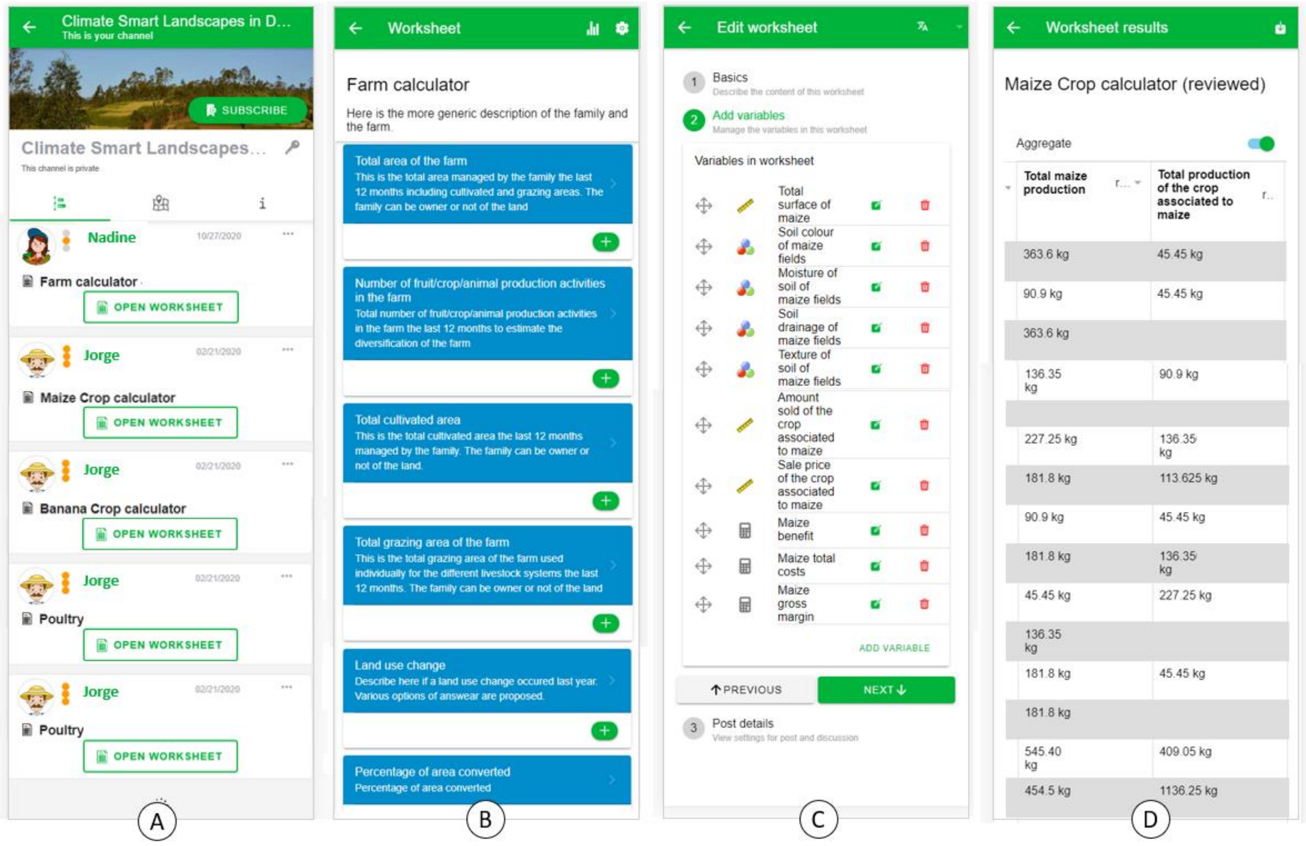

Figure 2. Visuals of GeoFarmer farm Calculator module; A shows the channel overview of available worksheets, B shows an example of a worksheet during data collection, C shows the edit mode of a worksheet, and D shows results of collected data in a worksheet.

Additional resources

Video	Introduction to GeoFarmer: https://www.youtube.com/watch?v=0m01T3CNBEk
Online course:	Introduction to GeoFarmer: https://learn.ciat.cgiar.org/
Brief	Eitzinger, A.; Bartling, M.; Feil, C.; Bonilla-Findji, O.; Andrieu, N.; Jarvis, A. (2020) GeoFarmer app: A tool to complement extension services and foster active farmers participation and knowledge exchange. Infonote. Cali (Colombia): International Center for Tropical Agriculture (CIAT); Salzburg (Austria): University of Salzburg Interfaculty Department of Geoinformatics (Z_GIS) 10 p.

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Appendices

Appendix 1. CSA monitoring Core questionnaire (CSA Calculator- Farm module)

Variable name	Description
Number of children of 0-5years old	Number of children for 0-5years of the household, the last 12 months
Number of children of 5-10 years old	Number of children of 5-10 years old of the houshold, the last 12 months
Number of children of 10-15 years old	Number of children of 10-15 years old ofthe household, the last 12 months
Number of young of 15-18 years old	Number of young of 15-18 years old of the household, the last 12 months
Number of adults 18-35 years old	Number of adults 18-35 years old of the household the last 12 months
Number of adults between 35 and 65 years old	Number of adults between 35 and 65 years old of the household the last 12 months
Number of adults > 65 years old	Number of adults > 65 years old of the household the last 12 months
Total area of the farm	This is the total area managed by the family the last 12 months including cultivated and grazing areas. The family can be owner or not of the land
Number of fruit/crop/animal production activities in the farm	Total number of fruit/crop/animal production activities in the farm the last 12 months to estimate the diversification of the farm
Total cultivated area	This is the total cultivated area the last 12 months managed by the family. The family can be owner or not of the land.
Total grazing area of the farm	This is the total grazing area of the farm used individually for the different livestock systems the last 12 months. The family can be owner or not of the land
Total fenced grazing area of the farm	This is the total fenced grazing area of the farm used individually for the different livestock systems the last 12 months. This area can be the same than the previous one if all the grazing area of the farm are fenced. The family can be owner or not of the land
Community grazing area	Use of a community grazing area the last 12 months
Total homegarden area of the farm	This is the total homegarden area that was managed by the family the last 12 months. The family can be owner or not of the land
Implementation of tree planting practice	Implémentation of tree planting (baobab, jujubier, tamarindus, goyava) the last 12 months
Implementation of Farmer Managed Natural Regeneration	Implémentation of farmer Managed Natural Regeneration the last 12 months
Implementation of Drought tolerant Improved Varieties	Implementation of drought tolerant Improved Varieties of millet, maize or groundnut the last 12 months
Implementation of reduced tillage	Implémentation of reduced tillage the last 12 months
Implementation of manure + microdose of inorganic Fertilizer	Implémentation of manure + microdose of Inorganic Fertilizer of NPK and urea the last 12 months
Implementation of organic fertilizer (Manure, compost)	Implémentation of organic fertilizer (Manure, compost) the last 12 months
Implementation of microdose of inorganic fertilizer of NPK-Urea	Implémentation of microdose of inorganic fertilizer of NPK-Urea the last 12 months
Use of a irrigation system in crops or homegardens	Use of a irrigation system in crops or homegardens the last 12 months
Name of the first crop grown in the homegarden	Name of the first crop grown in the homegarden the last 12 months
Amount self-consumed of the main crop in the homegarden	Amount self-consumed of the main crop in the homegarden the last 12 months. You can decide to fill an average amount per day, month or year
Name of the second crop grown in the homegarden	Name of the second crop grown in the homegarden
Amount self-consumed of the second main crop in the homegarden	Amount self-consumed of the second main crop in the homegarden the last 12 months. You can decide to fill an average amount per day, month or year
Name of the third crop grown in the homegarden	Name of the third crop grown in the homegarden
Amount self-consumed of the third main crop in the homegarden	Amount self-consumed of the third main crop in the homegarden the last 12 months. You can decide to fill an average amount per day, month or year
Amount of organic fertilizer used in the homegardens	Amount of organic fertilizer used in the homegardens
Average sales from homegardens	Average amount of sales coming from the homegardens the last 12 months. You can decide to fill an average amount per day, month or year
Land use change	Describe here if a land use change occured last year
Percentage of area converted	Percentage of area converted

Appendix 2. CSA monitoring Core questionnaire (CSA Calculator- Crop module)

Variable name	Description
Total surface	This is the total area of all the fields where the crop was grown the last 12 months
Soil colour	This is the colour of the soil(s) where the crop was grown. Four types of colours are considered:brown, red, yellow, grey
Soil moisture	This is the moisture of soils where the crop is grown. Two types are considered: 'moist' for soils without any significant water constraint, of sumides pour des sols sans contrainte hydrique (included irrigated soils). Put 'dry' if for significant periods of the growing season water is limited (evaporation exceeds the rainfall)
Soil drainage	This is the drainage of the soils where the crop is grown. Typically, clay soils with limited drainage should be classed 'poor'. Otherwise, put 'good'. This mainly affects N2O emissions from soil.
Texture of soil	This is the texture of the soils where the crop is grown. Three types of texture are considered. 'Coarse' includes sand, loamy sand, sandy loam, loam, silt loam, silt. 'Medium' includes sandy clay loam, clay loam, and silty clay loam. 'Fine' includes sandy clay, silty clay, and clay.
Associated crop	Crop associated to the main crop the last 12 months
Proportion of the associated crop	Proportion of field concerned by the association the last 12 months
Total production of the main crop	Total production of the whole fields where the main crop was grown the last 12 months
Total production of the associated crop	Total production of the associated crop the last 12 months
Main mineral fertilizer used on the crop	Name of the main mineral fertilizer used on the crop the last 12 months
Application method of the main fertilizer	Various application methods of the fertilizer are proposed
Application rate of the main mineral	Application rate of the second mineral fertilizer on the crop the last 12 months
Purchase price of the main mineral fertilizer applied	Purchase price of the main mineral fertilizer applied on the crop, possibility later to add the price of a seconf mineral fertilizer
Second mineral fertilizer used	Name of the second mineral fertilizer used on the crop the last 12 months
Method of application of the second	Various application methods of the fertilizer are proposed
Application rate of the second mineral	Application rate of the second mineral fertilizer on the crop
Purchase price of the second mineral	Purchase price of the second fertilizer applied to the crop
Organic fertilizer used	Different types of organic fertilizers are proposed
Application method of the organic	Various application methods of the fertilizer are proposed
Amount of organic fertilizer applied	Amount of organic fertilizer applied on the crop the last 12 months
Purchase price of organic fertilizer	Purchase price of organic fertilizer on the crop
Number of applications of the main	Number of applications of the main pesticide on the crop the last 12 months
Management of crop residues	Different management of crop residues are considered
Proportion of crop residues managed under this mode	The previous variable describes different types of management of crop residues, here should be estimated the proportion of the crop residues that is managed under this mode.
Main associated tree	Name of the main tree on the fields of the crop
Density of the main tree	Density of the main tree in the fileds of the crop
Change in compost additions	Compost addition change on the crop the last 12 months
Tillage change	Here we indicate if a change in tillage method occured last year on the fields of the crop the last 12 months. Different tillage change are proposed
Change in manure incorporation method	Change in manure incorporation method on the fields of the crop the last 12 months
Change in incorporation mode of crop	Change in the incorporation mode of crop residues on the fields of the crop the last 12 months
Cost of clearing	Cost of clearing of the fields of the crop before or at the beginning of the last growing season (external workers, rent of equipment)
Tillage cost	Tillage cost of fields of the crop the last 12 months (external workers, rent of equipment)
Purchase price of seeds	Purchase price of the seeds of the main crop the last 12 months
Seed purchase amount	Seed purchase amount for the main crop the last 12 months
Associated crop seed purchase amount	Amount purchased for the crop that is associated to the main crop
Associated crop seed purchase price	Associated crop seed purchase price
Sowing cost of millet fields	Sowing cost of fields of the crop the last 12 months (external workers, rent of equipment)
Application cost of pesticides	Total cost of application of pesticides (herbicides+insecticides) on the fields of the crop the last 12 months (purchase of pesticides, external workers, rent of equipment)
Cost of manual/mechanical weeding	Cost of mechanical or manual weeding of fields of the crop (external workers, rent of equipment)
Harvesting cost	Cost associated to the harvest of the fields of the crop the last 12 months (external workers)
Amount sold	Amount of the production for the main crop sold the last 12 months, without post-harvest processing
Sale price (non-processed)	This is the sale price of the non-processed product
Amount sold of processed product	Amount sold of finished product the last 12 months, in case of post-harvest processing by the farmer
Sale price of processed product	If the product is processed by the farmer, here indicate its sale price.
Amount sold of the associated crop	Amount sold of the crop associated to the crop the last 12 months
Sale price of the associated crop	Sale price of the crop associated to the main crop
Supply of calories to the family	This is the supply of calories considering the fraction of fresh product for the self-consumption of the familly.
Fodder production	This is the production in kg of fodder for this crop. It takes into account to the proportion of the crop residues left for animal grazing

Appendix 2. CSA monitoring Core questionnaire (CSA Calculator- Crop module) - continuation

Variable name	Description
Benefit	The benefit generated by the crop the last 12 months
Labor/mechanization total costs	Total labor and mechanization costs generated by the crop
Total cost of fertilizers	
Gross margin	This is the benefits minus cost
Supply of nitrogen by synthetic fertilizers	The calculation of the total supply of nitrogen by the synthetic fertilizers
Supply of nitrogen by organic fertilizers	Calculation of the supply of nitrogen by organic fertilizers
Supply of nitrogen by crop residues	Calculation of supply of nitrogen by crop residues
Direct N2O Emissions from Managed	
N2O from atmospheric deposition of N volatilised	annual amount of N2O emissions produced from atmospheric deposition of N volatilised from managed soils
Annual CO2 emissions from Urea	Annual CO2 emissions from Urea Fertilization of the crop the last 12 months
Nitrogen content value-Parameter	This is the N content of 1 kg of crop residues
Caloric value-Parameter	This is the caloric value for one kg of seed for this crop
Harvest index-Parameter	This is the ratio between seeds and the total biomass produced by the crop and that includes leaves, straw.
Emission factor for N2O emissions from N inputs-Parameter	EF1 for N additions from synthetic fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon [kg N2O–N (kg N)-1]
Emission factor from atmospheric deposition of N-Parameter	Emission factor for N2O emissions from atmospheric deposition of N on soils and water surfaces [kg N–N2O (kg NH3–N + NOx–N volatilised)-1]

Appendix 3. CSA monitoring Core questionnaire (CSA Calculator- Animal module)

Variable name	Description
Number of animals in juvenile phase	Number of animals in this phase the last 12 months.
Number of self-consumed juvenile animals	Number of self-consumed animals in this phase the last 12 months.
Number of purchased juvenile animals	Number of purchased animals in this phase the last 12 months.
Number of sold juvenile animals	Number of cattle in juvenile phase sold the last 12 months.
Purchase price of an animal in juvenile phase	Average purchase price of an animal in this phase the last 12 months.
Sale price of an animal in juvenile phase	Average price of an animal of this phase the last 12 months.
Type of grazing of juvenile animal	Type of grazing of animals of this phase the last 12 months.
Quality of legume and grasses grazed by juvenile animals	Quality of legume and grasses grazed by an animal of this phase. Three levels of quality are considered.
Type of mix feed for juvenile animals	Type of mix feed for animals of this phase.
Percentage of the juvenile animal diet covered with feed mix	Percentage of the diet of an animal of this phase covered with feed mix, instead of grazing.
Expenses linked to the management of an animal in juvenile phase	The average value of the expenses the last 12 months (feed, veterinary care).
Main management system applied to manure of juvenile animals	Main management system applied to manure produced by animals of this phase.
Percentage of juvenile animal manure managed this way	Percentage of the produced manure that was managed under the system described in the previous variable.
Lenght of the cycle of the crop where the manure was applied	Lenght of the cycle of the main crop where the manure was applied.
Number of animals in productive phase	Number of animals in this phase the last 12 months.
Number of self-consumed productive animals	Number of self-consumed animals in this phase the last 12 months.
Number of purchased productive cattle	Number of purchased animals in this phase the last 12 months.
Number of sold productive animals	Number of animals in juvenile phase sold the last 12 months.
Purchase price of an animal in productive phase	Average purchase price of an animal in this phase the last 12 months.
Sale price of an animal in productive phase	Average price of an animal of this phase the last 12 months.
Type of grazing of productive animals	Type of grazing of animals of this phase the last 12 months.
Quality of legume and grasses grazed by productive animals	Quality of legume and grasses grazed by animals of this phase. Three levels of quality are considered.
Type of mix feed for productive animals	Type of mix feed for animals of this phase.
Percentage of the productive animal diet covered with feed mix	Percentage of the diet of an animal of this phase covered with feed mix, instead of grazing.
Expenses linked to the management of a productive animal	The average value of the expenses the last 12 months (feed,veterinary care).
Main management system of manure of productive animals	Main management system applied to manure produced by an animal of this phase.
Percentage of productive animal manure managed this way	Percentage of the produced manure that was managed under the system described in the previous variable.
Lenght of the cycle of the crop where the manure was applied	Lenght of the cycle of the main crop where the manure was applied.
Number of animals in non-productive phase	Number of animals in this phase the last 12 months.
Number of self-consumed non-productive animals	Number of self-consumed animals in this phase the last 12 months.
Number of purchased non-productive animals	Number of purchased animals in this phase the last 12 months.
Number of sold non-productive animals	Number of animals in juvenile phase that were sold the last 12 months.
Purchase price of an animal in non-productive phase	Average purchase price of an animal in this phase the last 12 months.
Sale price of an animal in non-productive phase	Average price of an animal of this phase the last 12 months.
Type of grazing of non-productive animals	Type of grazing of animals of this phase the last 12 months.
Quality of legume and grasses grazed by non-productive animals	Quality of legume and grasses grazed by animals of this phase. Three levels of quality are considered.
Type of mix feed for non-productive animals	Type of mix feed for animals of this phase.
Part of non-productive animal diet covered with feed mix	Percentage of the diet of an animal of this phase covered with feed mix, instead of grazing.
Expenses management of an animal in non-productive phase	The average value of the expenses the last 12 months (feed, veterinary care) for an animal of this phase.
Main management system of manure of non-productive animals	Main management system applied to manure produced by animals of this phase.
Percentage of non-productive animal manure managed this way	Percentage of the produced manure that was managed under the system described in the previous variable.
Lenght of the cycle of the crop where the manure was applied	Lenght of the cycle of the main crop where the manure was applied.
Fodder demand	Fodder demand the last 12 months for the animals (juvenile+productive+non-productive)
Supply of calories to the family	Supply of calories by animals the last 12 months (juvenile+productive+non-productive)
Benefit	Total benefit for this livestock production activity (juvenile+productive+non-productive)
Total cost	Total cost for this livestock production activity (juvenile+productive+non-productive)
Gross margin	Gross margin of the livestock activity
Total CH4 Emissions	Total CH4 Emissions (Gg CH4 year-1)

Appendix 3. CSA monitoring Core questionnaire (CSA Calculator- Animal module) - continuation

Variable name	Description
Total direct N2O emissions	Total direct N2O emissions in kg N2O yr-1
Total indirect N2O emissions	Total direct N2O emissions in kg N2O yr-1
CH4 emissions from Manure Management	CH4 emissions from Manure Management for the animals (juvenile+productive+non-productive) the last 12 months (Gg CH4 yr-1)
CH4 Emissions from Enteric Fermentation	Methane Emissions from Enteric Fermentation for the animals (juvenile, productive, non-productive) the last 12 months (Gg CH4 yr-1)
Annual average nitrogen excretion rates	Annual average nitrogen excretion rates in kg N animal-1 yr-1
N2O emissions from manure management Juvenile	N2O emissions from manure management in kg N2O yr-1
N2O emissions from manure management Productive	N2O direct emissions from manure management in kg N2O yr-1
N2O emissions from manure management Non Productive	N2O direct emissions from manure management in kg N2O yr-1
Indirect N2O emissions Volatilisation N from manure management	Indirect N2O emissions due to volatilisation of N from manure management
NO2 emissions by urine and dung grazing Juvenile	NO2 Direct emissions by urine and dung by grazing animals
NO2 emissions by urine and dung grazing Non Productives	NO2 Direct emissions by urine and dung by grazing animals
NO2 emissions by urine and dung grazing Non Productives	NO2 Direct emissions by urine and dung by grazing animals
N2O indirect emissions from manure management Juvenile	N2O indirect emissions (volatilisation) from manure management in kg N2O yr-1
N2O indirect emissions from manure management Productive	N2O indirect emissions (volatilisation) from manure management in kg N2O yr-1
N2O indirect emissions from manure management Non Productive	N2O indirect emissions (volatilisation) from manure management in kg N2O yr-1
CH4 Emission factor for Manure Management-Parameter	CH4 emission factor for Manure Management-Parameter (kg head-1 yr-1)
Enteric fermentation emission factor-Parameter	Entérique fermentation factor (kg CH4
Tropical livestock unit fodder demand-Parameter	Fodder demand in kg of biomass per tropical livestock unit
Nitrogen excretion rate-Parameter	Nitrogen excretion rate (KG N (1000 KG animal mass)
N2O direct emission factor for manure Juvenile-Parameter	Emission factor for direct N2O emissions from manure management system, kg N2O-N/kg N
N2O direct emission factor for manureProductive-Parameter	Emission factor for direct N2O emissions from manure management system, kg N2O-N/kg N
N2O direct emission factor for manureNonProductive-Parameter	Emission factor for direct N2O emissions from manure management system, kg N2O-N/kg N
NO2 emission factor atmospheric deposition of nitrogen-Parameter	emission factor for N2O emissions from atmospheric deposition of nitrogen on soils and water surfaces in kg N2O-N (kg NH3-N + NOx-N volatilised)-1
Caloric value of meat-Parameter	This is the caloric value for 1 kg of meat

Appendix 4. Informed Consent

Informed Consent

(Included in the enumerators introductory discussion with the farmer)

Good morning/afternoon.

My name is _Enumerator; and I'm part of the [Program name] team working in [Study site name].

Informed Consent:

With the knowledge of [local implementing partners and local authorities, we are conducting an agricultural survey with selected farmers in the village. This is to help us understand how you are affected by the changing climate, and how you are responding through appropriate agricultural practices.

Your participation in this survey involves no risk of harm, it's absolutely **voluntary** and it **does not involve any type of commitment or monetary compensation** from [Program name and local implementing partners].

The interview will last around [1 hour].
The information that you will provide will be used exclusively for agricultural research purposes. The collected data will be analyzed in **a confidential way** (your identity will not be shared) by scientist from [Program name and local implementing partners] and the CGIAR. The local government authorities and you have the right to request for a report resulting from this exercise.

Do you give your consent to be part of this interview/study?

(if answer is) Yes____, then we start the interview. Otherwise we acknowledge the time spent by the farmer and say good-bye.

(If answer is yes) We ask: "Would you agree that we take some photographs? They will be used only for documenting and illustrating this research (not for any commercial purpose)?
Yes _______ No ____