

# Info Note

## Comparison of online greenhouse gas accounting tools for agriculture

*Six tools that support the assessment of climate change mitigation in the land use sector*

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### Key messages

- Six online greenhouse gas (GHG) accounting tools were identified and analyzed to determine their advantages and disadvantages to how they estimate GHG emissions and emission reductions and provide context-relevant mitigation options with details regarding mitigation potential and potential trade-offs.
- The tools are the CCAFS Mitigation Options Tool (CCAFS-MOT), the Agriculture and Land Use Greenhouse Gas Inventory (ALU) Software, the Small-Holder Agriculture Monitoring and Baseline Assessment (SHAMBA), the EX-Ante Carbon-balance Tool (EX-ACT), the Cool Farm Tool (CFT), and the Carbon Benefits Project (CBP).
- This comparison aims to help potential users to better understand in which projects and activities the GHG accounting tools will be most relevant.
- Differential features include data required, emission factors used, whether mitigation options are identified, and usability at different geographic scales.

The CCAFS-MOT is a Microsoft Excel-based tool that uses several different empirical models to estimate greenhouse gas (GHG) emissions from crops, grassland and livestock. In this Info Note we compare five other greenhouse gas accounting tools for agriculture to the CCAFS-MOT to help users to identify the most suitable, accessible, freely available tool for identifying mitigation options for agriculture. The other tools are the Agriculture and Land Use Greenhouse Gas Inventory (ALU) Software, the Small-Holder Agriculture Monitoring and Baseline Assessment (SHAMBA), the EX-Ante Carbon-balance Tool (EX-ACT), the Cool Farm Tool (CFT), and the Carbon Benefits Project (CBP).

### ALU Agriculture and Land Use National Greenhouse Gas Inventory Software

- **Developer:** Colorado State University
- <https://www.nrel.colostate.edu/projects/alusoftware/home/>

The ALU software reports GHG emissions from agriculture and other land uses in line with the United Nations Framework Convention on Climate Change (UNFCCC). The ALU software allows users to estimate GHG emissions and removals associated with agricultural and forestry activities; with particular focus on CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> emissions and removals. According to the website, the software provides a mitigation analysis that allows the user to identify potential reductions using the inventory as a baseline. The ALU download page contains a FAQ section on software use and installation and also a 20-minute instructional video. There are also external resources provided which give the user a better understanding of where the default factors were obtained.

Reporting GHG emissions on a national level is often challenging; this software aims to simplify the reporting of GHG emissions to the UNFCCC. The inventory has been divided into three modules which are accessible from a single page: Module 1: Specify Activity Data (Primary and Secondary Data Specification), Module 2: Specify Emissions/Stock Change Factors, and Module 3: Inventory Calculations. Default IPCC emission factors are provided for use in Module 2, although country specific emission factors can be used if available.

There are two ALU versions available; one uses the 2006 IPCC Guidelines for National Greenhouse Gas Inventories while the other version uses the 1996 IPCC Guidelines and IPCC Good Practice Guidance Documents (2000 and 2003).

Each module allows quality assurance and quality control reviews to be completed by the user, with results being checked by the developing team to ensure data integrity. Once the data has been added to the software, there is an option to export the data to excel. The software also allows the integration of spatial data, such as remote sensing, alongside national data on agriculture and forestry. The data is then used to create an emissions report. The user can choose to create either a standard emissions report which provides the data obtained in Module 3, or they can create a UNFCCC emissions report which creates an additional module; Module 4: Agriculture, or Module 5: Land Use Change and Forestry. There is an option to add UNFCCC macros (typically used to replace a repetitive series of keyboard and mouse actions) to the reporting file to allow the data to be integrated into the secretariat software.

## How to access ALU?

The user must register before the tool can be downloaded, the request will take **2-3 days to process**. The user must have “administration” privileges on their computer. Access to an email address as login credentials are emailed to the user. There are several steps to use each module which increase the amount of time needed to obtain estimates, especially if the user has not watched the instructional video.

## Small-Holder Agriculture Monitoring and Baseline Assessment (SHAMBA)

- **Developer:** University of Edinburgh

- <https://shambatool.wordpress.com/outputs/>

The SHAMBA is a carbon accounting tool focused on tropical areas. The tool identifies changes in carbon stocks in soil and woody biomass as well as GHG emissions that result from changes in agricultural practices and tree planting. Results can be calculated either annually or over a specific accounting period.

The tool creates two models, namely 1) a baseline scenario based on current land management activities and 2) an intervention scenario that considers climate-smart agriculture (CSA) practices. A user guide explains how to install and use the tool. The SHAMBA methodology is provided, and there are examples of how SHAMBA has been used in Plan Vivo projects.

The aim of the tool is to make agricultural and forestry carbon offsetting understandable and profitable for communities. Data requirements include plot location, plot area, tree stocking density, growth rate, and tree mortality. Once this data has been entered it is combined with existing data in the SHAMBA tool to provide a more detailed and accurate account of a project's carbon benefits.

The user does not require a scientific background or access to scientific literature to use SHAMBA, as the tool

contains databases of emission factors, tree allometry, and soil and climate information. SHAMBA uses the Roth C model for estimating changes in soil carbon stocks resulting from implementation of CSA practices, and IPCC modules for non-CO<sub>2</sub> greenhouse gases.

Multiple baseline and intervention combinations can be created with new additions automatically displayed in a drop down list and the saved project data can be imported into a number of platforms such as MS-Excel, R, and Python. The SHAMBA tool allows estimates to be made at the hectare level, as opposed to a regional level, which provides a greater level of accuracy. When estimates are made on a regional level, this can be detrimental to high-performing farmers, as overall values tend to be lowered. Estimating on a micro-level can greatly increase the number of credits that high-performing farmers can achieve. This tool also works with several GHG pools, including emissions from burning, organic nitrogen emissions, and nitrogen fertilizer emissions; this can also increase the number of credits issued to smallholders. Users are able to enter the data by themselves instead of having to employ specialist monitoring consultants; this reduces the financial cost of monitoring, could improve the profitability for smallholders, and encourage communities to start their own projects.

## How to access SHAMBA?

The tool has been trialed in 30 projects in Mexico and Uganda as of 2018. It is not yet suitable for worldwide use. At present the tool exists as a computer code with a basic user interface. The developers intend to create an online platform and interface that will be accessible globally. SHAMBA requires Python v2 to run the program. Data must be checked manually to ensure integrity, and the baseline and intervention scenarios are calculated based on the general data. This cannot be changed once the baseline and interventions have been created. As only one baseline/intervention option can be plotted at a time, this can be time-consuming if you have a large amount of data to add.

## EX-Ante Carbon-balance Tool (EX-ACT)

- **Developer:** FAO

- <http://www.fao.org/tc/exact/ex-act-home/en/>

The EX-ACT tool is an excel-based tool developed by the Food and Agriculture Organization of the United Nations (FAO). EX-ACT is an appraisal system that provides estimates on how the carbon balance is impacted by agriculture and forestry development projects. It estimates C stock changes and GHG emissions per unit of land. It compares the amount of carbon emitted or sequestered due to the implementation of the project against the 'business-as-usual' scenario.

An EX-ACT tool has also been developed specifically for value chains. It provides information on climate mitigation,

resilience and socio-economic performances of the food value chain at micro and intermediate levels (by agent, by stage and for the whole value chain).

There are several guidance documents available to download via the website, in several languages, that provide a concise overview of methodology, data needs, application, and use of the tool. The first part of the guidance booklet is structured for decision-makers; the second is for tool-users. There is also a User Manual, Technical Guidelines, Blue Carbon Guidelines, and EX-ACT Value Chain Guidelines as well as links to related guidelines for further information. An e-learning course may aid users as well as annual training and capacity-building workshops.

EX-ACT can help project designers identify which project activities will have the highest benefits with regards to both the economy and climate change mitigation. The EX-ACT tool can be applied to a wide variety of development projects, including all AFOLU sub-sectors such as sustainable land management, livestock, production intensification, and food security. While it is mostly used at the project level, it can also be scaled up to sector level or used for policy analysis. EX-ACT is available in several languages; English, French, Portuguese, and Spanish.

The EX-ACT tool has been used in projects across the globe, as well as value chains related to agriculture and agro-processed products. As such, it has aided policy makers in agriculture and forestry planning.

### How to access EX-ACT?

The tool consists of a set of linked excel sheets that comprise nine topic modules. The excel spreadsheet is structured in a logical manner that makes the tool quick and relatively easy to use and requires only a small amount of data. The EX-ACT tool uses IPCC Tier 1 default values and/or region specific coefficients (Tier 2). The tool publishes the results in the form of maps, tables and FAO statistical data. There is also space at the end of the spreadsheet that allows the user to undertake additional calculations if required. The tool may be difficult for non-experts with little experience using greenhouse gas accounting tools. The results in table and graph format may be hard to interpret without prior experience. Therefore, the guidance notes should be read beforehand to gain the maximum benefit.

### Cool Farm Tool (CFT)

- **Developer:** University of Aberdeen and Cool Farm Alliance members
- <https://coolfarmtool.org>

The CFT was originally an excel-based tool but is now an online tool. It aims to help farmers choose crop and livestock-related management options that will improve their environmental performance and allow them to

assess and quantify their improvements over time. The CFT can be used to calculate emissions for more than 20 crops and different livestock types around the world.

The GHG section contains a brief overview of the tool, data requirements, and video demos. There is also a user guide available for download and a section that lists the methodologies used in the development of the tool.

The GHG emissions are calculated using empirical research and IPCC methods, and it includes calculations of soil carbon sequestration. The CFT provides GHG emissions (in carbon equivalent) per kilogram of product or per area (hectare). While the CFT is typically used up to the farm gate, one can also estimate GHG emissions from fuel associated with the transport of products beyond the farm gate.

### How to access the Cool Farm Tool?

The CFT is free for farmers and relatively easy to use. The user must first register with an email address. A rough estimate can be obtained within 10-15 minutes, but a more accurate assessment requires 30-60 minutes of data entry.

The section on electricity and fuel consumption is the lengthiest section of the CFT. While the data is stored confidentially, there is the option to share the data using 'share codes'. Users of the CFT can join the Cool Farm Alliance to share information and to contribute to the development of the tool.

### Carbon Benefits Project: Modelling, Measurement and Monitoring (CBP)

- **Developer:** Colorado State University
- <http://www.carbonbenefitsproject.org>

The CBP tool is an online modelling tool that measures, monitors, models, and forecasts GHG emissions and changes in carbon stocks. The tool produces a standardized system that can be used by the Global Environment Facility (GEF) and other sustainable land management (SLM) projects.

On the main page where the tool is accessed there is the opportunity to discuss and to ask questions about the tool with other users via a Google Group in the 'Contact us' section. This group provides updates on the tool and allows users to notify the developers of any problems, or to request system improvements.

The tool includes three sections: 1) 'Strategy for tracking carbon and greenhouse gas benefits,' which allows the user to identify where efforts should be focused; 2) 'Measuring and monitoring,' which provides guidance on measuring and monitoring carbon stock changes and GHG emissions; and 3) 'Analysis tools,' which provides guidance on the most appropriate functionalities for each project type. Additional information can be obtained via the 'help' button found at the top of the page, which

allows the user to access in-depth tutorials for each section, FAQ, glossary and definitions, IPCC GHG inventory documentation, and updates and revisions.

There is an option of using the three tools to estimate the impact that a land management project will have on carbon stock changes and GHG emissions; these include the 'Simple Assessment', the 'Detailed Assessment', and the 'Dynamic Modelling Option'. The tool also provides a Cost-Benefit Analysis (CBA) and a social analysis called the Drivers-Pressures-States-Impacts-Responses (DPSIR) Framework.

Once the data input has been completed, the user can generate a report that provides the carbon and/or GHG balance related to the project.

The 'Simple Assessment' is able to produce a quick assessment of changes in carbon stocks and GHG emissions during different stages of the project, including the proposal. This option requires information on land use changes (LUC) and/or livestock production, and it uses standard information on a variety of trees, crops, shrubs, grasses, and their management, chosen via a dropdown list. The simple assessment tool does not allow the user to provide detailed information and is best suited to sustainable land management projects that involve either a small amount of land use/management changes over a small area, or on a few combinations of soil type and climate.

The 'Detailed Assessment' can be used for detailed reporting on changes in carbon stocks and GHG emissions. This option requires the user to enter information regarding LUC and/or livestock production, and allows the user to create specific tree, crop, shrub, and grass types using data obtained from field measurements and other local datasets. The detailed assessment tool is best suited for projects that focus mostly on climate change mitigation and/or have several land management changes on areas that contain several soil types and climate.

The 'Dynamic Modelling Option' estimates soil and biomass carbon stock changes by utilizing the Century Model. It is best implemented in projects that want to make a detailed analysis of soil carbon stock changes. Users of the dynamic modelling option tool require experience of geographical information systems (GIS), familiarity with modelling, and a background in soil carbon inventories. This tool is best suited for projects that want to assess carbon stock change associated with complex land use or land management changes over a large area with multiple soil and climate combinations.

Once the analysis has been completed, the user has the option of generating a report in the form of a graph/chart that is based on the UNFCCC GHG source categories, a summary report, or a detailed report. Both reports can be used to assist CBP tool users, the GEF, and implementing agencies (e.g. World Bank, IFAD, etc.). The

summary report can be used to identify the overall GHG balance of the related projects, and the detailed report is useful for examining the equations that are used in the GHG flux calculations.

## How to access the Carbon Benefits Project tool?

The CBP is free, user-friendly, and can be used at all stages of a project. To use the 'Dynamic Modelling Option,' the user will have to download the GEFSOC modelling system and the user's manual. There are tutorials available to explain how to use the CBP. If the tool is under maintenance, access is not been possible (as is the case in December 2016).

## Comparison among the six accounting tools for agriculture

As shown in the comparison in Table 1, all tools are free to use and are able to identify GHG emissions based on current agricultural practices. All tools provide GHG emissions for crops, rice, grassland, and livestock, with the exception of the SHAMBA which focuses on agroforestry.

The CCAFS-MOT is the only tool that suggests mitigation options; the ALU provides mitigation analysis as a secondary focus to identify potential reductions using the inventory as a baseline.

The CCAFS-MOT, SHAMBA, and EX-ACT tools are MS Excel-based while the other tools are accessed online. The Excel-based tools do not require the user to register. The CCAFS-MOT and EX-ACT tools do not need specific software to run, however, SHAMBA requires Python to be installed before it can run.

Each tool provides instructions on how to use them; the ALU software and the CFT provide instructional videos. EX-ACT provides several in-depth manuals and hosts an e-learning course and workshops. The SHAMBA and the CCAFS-MOT provide a guidance document (user's guide), and the CBP provides a wide range of tutorials on each aspect of the tool. The CCAFS-MOT was the only tool to provide an example document that showed the user the data requirements.

The ALU software requires a larger data input and a greater level of expertise compared to the other tools. The CCAFS-MOT tool has minimum data and time requirements and is arguably the easiest tool to access and use.

Each tool uses default factors, although the ALU software is the only tool that has taken steps to ensure data integrity. The CBT uses default factors for the 'Simple Assessment' but the 'Detailed Assessment' requires data obtained from field measurements or other local datasets. The ALU software and the SHAMBA tool store data entered by users to create a comprehensive database

that is used to help inform future users and increase the accuracy of the results; the other tools do not currently do this.

The CCAFS-MOT, EX-ACT, CBT, and ALU software can be used worldwide, and the data can be used to inform policy makers. The CFT can also be used worldwide but it is focused on farm GHG emissions. The SHAMBA tool has been designed for use by smallholders in tropical regions and can be used in carbon accounting projects.

The CCAFS-MOT and CFT only allow one crop to be entered at a time, and the SHAMBA tool can only plot a single baseline-intervention option at a time. The EX-ACT and CBT allow the user to input a wide range of data at the same time, which can greatly reduce the amount of time required to obtain results. The ALU software allows the user to create a database that focuses on several different activities, although it is unclear how many activities can be completed or shown at the same time, as the instruction video showed only a single activity being entered into the example database.

Results for the CCAFS-MOT and EX-ACT are shown in either graph or table format. The CFT shows emissions in the form of a pie chart as data is being entered; final results are shown in a single comprehensive table that is easy to interpret. The ALU shows the results in table format and also allows the user to see what equations were used to obtain the results; these results appear to require a greater level of scientific understanding to allow the user to interpret them. The CBT can show the results in the form of a graph or a report; the report can be in summary or detailed format. The data obtained from each of the six tools can be used for reporting purposes.

The CCAFS-MOT, CFT and SHAMBA tool are only available in English, the ALU software is available in English and Chinese, the EX-ACT is available in English, French, Spanish, and Portuguese; and the CBP is available in English, Spanish, French, Portuguese, Russian, and Chinese.

**Table 1.** Comparison of greenhouse gas accounting tools

Tool	CCAFS-MOT	ALU	SHAMBA	EX-ACT	CFT	CBP
<b>Full name</b>	CGIAR Research Program on Climate Change, Agriculture and Food Security - Mitigation Options Tool	Agriculture and Land Use National Greenhouse Gas Inventory Software	Small-Holder Agriculture Monitoring and Baseline Assessment	EX-Ante Carbon-balance tool	Cool Farm Tool	Carbon Benefits Project: Modelling, Measurement and Monitoring
<b>Developer</b>	University of Aberdeen	Colorado State University	University of Edinburgh	FAO	University of Aberdeen and Cool Farm Alliance	Colorado State University, partner universities (East Anglia, Leicester), UNEP
<b>Software</b>	Excel	User interface	Python	Excel	User interface	ArcGIS
<b>Impacts Assessed</b>	GHG emissions from management practices and mitigation options	GHG emissions	GHG emissions	GHG impacts of projects and policies	GHG emissions	GHG emissions and carbon sequestration
<b>Registration required</b>	No	Yes	No	No	Yes	Yes
<b>Expertise required</b>	Low	No information	High	Medium	Medium	No information
<b>Availability</b>	Free	Free	Free	Free	Free	Not available at the moment
<b>Expertise required</b>	Easy	Moderate	Easy	Moderate	Moderate	High
<b>Geographic Scope</b>	Country, region, local	National/ Sectoral	Smallholder farms	National/ Sectoral	Local	National/ Sectoral
<b>Data requirements</b>	Low	High	High	High	High	Very High
<b>Models</b>	Mixed	IPCC 2006 (Tier 1 and 2 methods)	RothC model and the IPCC	IPCC 2006 default values (Tier 1) and/or region specific (Tier 2)	Mixed	No information
<b>Scale</b>	Hectare	No information	No information	Landscape, total and hectare	Farm	Project (ha)

## Links to accounting tools

- CGIAR CCAFS “Mitigation Options Tool for Agriculture (CCAFS-MOT)”  
<https://ccaafs.cgiar.org/mitigation-option-tool-agriculture>
- Colorado State University “Agriculture and Land Use National Greenhouse Gas Inventory Software”  
<http://www.nrel.colostate.edu/projects/ALUsoftware/>
- The University of Edinburgh “Small-holder agriculture mitigation assessment benefit tool”  
<https://shambatool.wordpress.com/>
- Food and Agriculture Organization of the United Nations “EX-Ante Carbon Balance Tool (EX-ACT)”  
<http://www.fao.org/tc/exact/ex-act-home/en/>
- Cool Farm Alliance “Greenhouse Gases”  
<https://coolfarmtool.org/coolfarmtool/greenhouse-gases/>
- Colorado State University “Carbon Benefits Project: Modelling, Measurement and Monitoring”  
<http://carbonbenefitsproject-compa.colostate.edu/index.htm>

## Further reading

- Columb V, Touchemoulin O, Bockel L, Chotte JL, Martin S, Tinlot M, Bernoux M. 2013. [Selection of appropriate calculators for landscape-scale greenhouse gas assessment for agriculture and forestry](#). *Environmental Research Letters* 8:015029.
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- Richards MB et al. 2016. [Limits of agricultural greenhouse gas calculators to predict soil N<sub>2</sub>O and CH<sub>4</sub> fluxes in tropical agriculture](#). *Scientific Reports* 6.

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## About CCAFS Info Notes

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is led by the International Center for Tropical Agriculture (CIAT). CCAFS brings together some of the world's best researchers in agricultural science, development research, climate science and Earth System science, to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security. Visit us online at <https://ccaafs.cgiar.org>.

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