



Smallholder Beans, Nicaragua

Cool Farming Options Pilot with Catholic Relief Services

Catholic Relief Services (CRS) is an international humanitarian agency that assists more than 100 million impoverished and disadvantaged people in over 100 countries on 5 continents. The CRS-led *Alliance to Create Rural Development Opportunities through Agro-enterprise Relationships* (ACORDAR) in Nicaragua is an example of CRS' sustainable agriculture and agro-enterprise development work. The \$53 million, public-private sector, five-year initiative directly benefits 7,000 producers organized in 107 cooperatives in 50 municipalities around the country and includes producers of beans, roots and tubers, fruits and vegetables, cocoa and coffee.

Sponsor Goals for use of the Cool Farm Tool

In recent years, CRS agriculture specialists have been integrating approaches to increase the resiliency of poor/ vulnerable communities to the effects of climate change through agro-enterprise programs such as ACORDAR. The quantification of the greenhouse gas emissions of different farming practices complements CRS' efforts to support farmers to adapt to a changing climate. They are using the Cool Farm Tool (CFT) to assess the emissions of different types of bean farming represented within the ACORDAR project. With these baselines, they will then be able to model the key practices they are promoting such as new bean varieties, irrigation and the optimized use of inputs, to understand the associated climate effects. The ultimate goal of the work is to build the capacity of CRS and its partners to analyze the GHG impact of agricultural products, to inform future technical recommendations and to communicate environmental impact to potential markets.



Red bean grower in ACORDAR project

Nicaragua produces 70% of the red beans consumed in Central America and red beans are a pivotal income generating and food security crop for rural communities. Given that the majority of these farmers are dependent on rain for crop irrigation and that beans are sensitive to variations in temperature and rainfall patterns, these farmers are already experiencing negative effects from climate change, most notably in delayed or unpredictable rainy seasons and excessive rain in some periods. With traditional varieties, some farmers have reported a 50% drop in yields in recent years from 900-1000 lbs/acre to only 400-500lbs/acre.

Farming System



The farmers being profiled by CRS cultivate black and red beans on small plots between 0.5-3 hectares each. There are approximately 3,265 bean farmers in the ACORDAR project, organized into 53 farmer cooperatives and farmer groups. CRS analyzed three types of bean farming practices with the Sustainable Food Lab: mechanized cultivation with tractors, tillage with animals, and manual cultivation with hand tools only. Many farmers rotate the beans with another crop such as tomatoes, or intercrop beans with perennials like coffee and cocoa and the majority do not have irrigation. Kidney bean growers can cultivate under forest trees also.

Farmers using hand tools practice minimum till practices, rotating the soil only for sowing. These farmers typically do not burn their residues, but leave them on the field as mulch to further increase soil fertility and capture moisture. Farmers tilling with oxen or tractors are practicing conventional or reduced tillage, aerating their soil to facilitate root development.

Methodology

Given the difficulty of collecting accurate data from smallholders, the following methodology was developed to provide CRS and the farmer organizations the most useful type of results while balancing the need for detail, accuracy and cost-effectiveness.

In order to get a sample of farms that reflected the different harvest seasons and tillage techniques typical of bean farmers within the ACORDAR project, a CRS agronomist collected data from six farms in each of the following categories. Overall, 18 farms were analyzed between April 2011 and May 2012 (six from each harvest season).

- a. 'Primera'- harvest season from May-August. Tends to have excessive rainfall and floods. Sample included farmers practicing mechanized, manual and animal soil preparation techniques.
- b. 'Postrera'- harvest season from September- December. Can have drought conditions. As with primera, sample included farmers practicing mechanized, manual and animal soil preparation techniques.
- c. 'Apante'- harvest from November to February. This is an additional season in humid regions. Because these farms are usually located in mountainous regions, tractors are not used for soil preparation. Thus, the samples included only manual and animal soil preparation techniques. Additionally, some farmers in this in this group were listed as experiencing low yields due to delayed rain patterns this year.

The farms sampled in this study ranged from .18 to 2.8 ha in size. Yields varied between .13 to 2.26 tonnes/ha, with an average of .8 tonnes/ha.

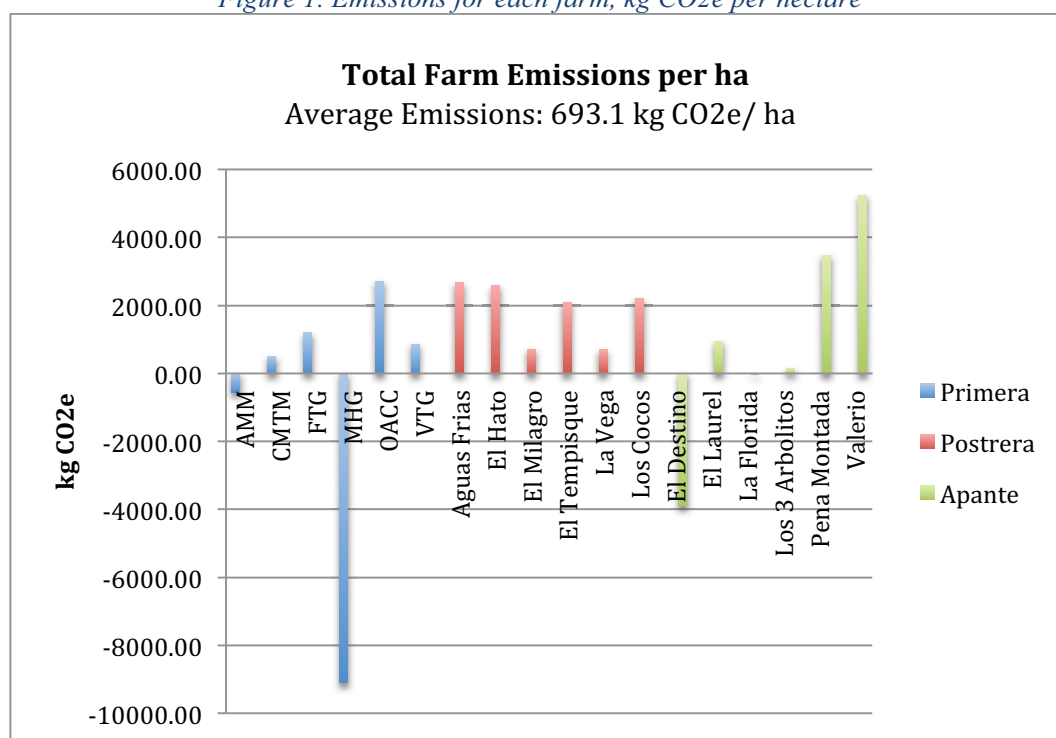


Results

The boundary set for the initial data collection varied between harvest season groupings. While data pertaining to the transport of the product from the farm to the nearest buying center was included in some of the Primera files, only emissions up to farm gate were included in the Postrera and Apante files. In order to standardize emissions between all three groups of farmers, the transport emissions pertaining to the Primera files were omitted from this analysis.

Figure 1 shows the range of emissions for the 18 farms surveyed in kilograms of carbon dioxide equivalents (CO₂e) per hectare, with these farmers producing average emissions of 693.1 kg CO₂e per ha.

Figure 1. Emissions for each farm, kg CO₂e per hectare



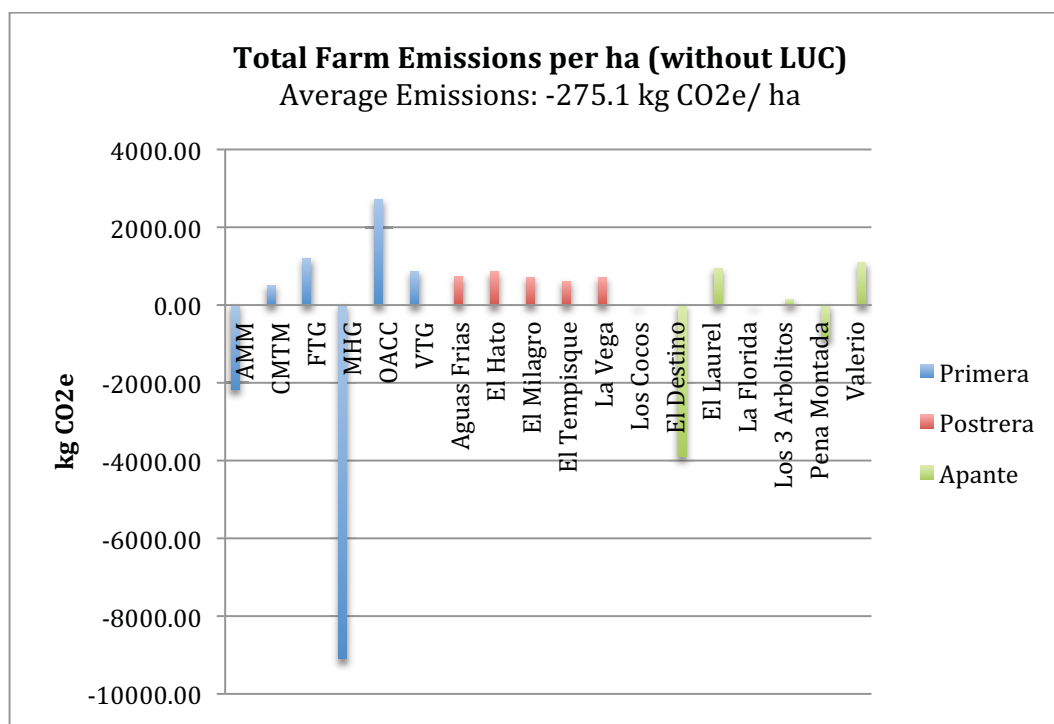
The range of emissions between farms varies from -9,098.9 to 5,225.9 kg CO₂e/ha. The factor that is most responsible for the highest and lowest emissions of the farms sampled (Valerio/ Pena Montada and MHG, respectively) is related to different components of carbon stock change. Farm 'MHG' is sequestering carbon mainly due to trees on farm, while Pena Montada and Valerio have the highest emissions based largely on a land conversion from grassland to arable within the last 20 years.

We have reason to believe that the average emissions of these farms may actually be lower than these estimates. Seven farms reported land use change from grassland to arable production in the last 20 years. We have learned that in some cases bean farms were planted not on former pasture or grassland but instead on 'tacolates' or degraded land. This means that although this land use change was reflected in the tool as a switch from grassland to arable (which would have significant emissions), the change from degraded land to arable would more likely have a positive impact on climate and a negative impact overall on emissions as the cropland would represent an increase in carbon stock on this land. Unfortunately, we are unsure how many of the farms in this sample actually switched from grassland to arable production and/ or how many switched from



degraded land to arable production. If we remove land use change from the emissions analysis, the average emissions drop from 693.1 to -275.1 kg CO₂e per ha (as seen in Figure 2).

Figure 2. Emissions for each farm without Land Use Change, kg CO₂e per hectare



Depending on the degree to which degraded land is being restored for crop production, this representation of land use may in fact be a more accurate assessment of emissions for this sample of farmers.

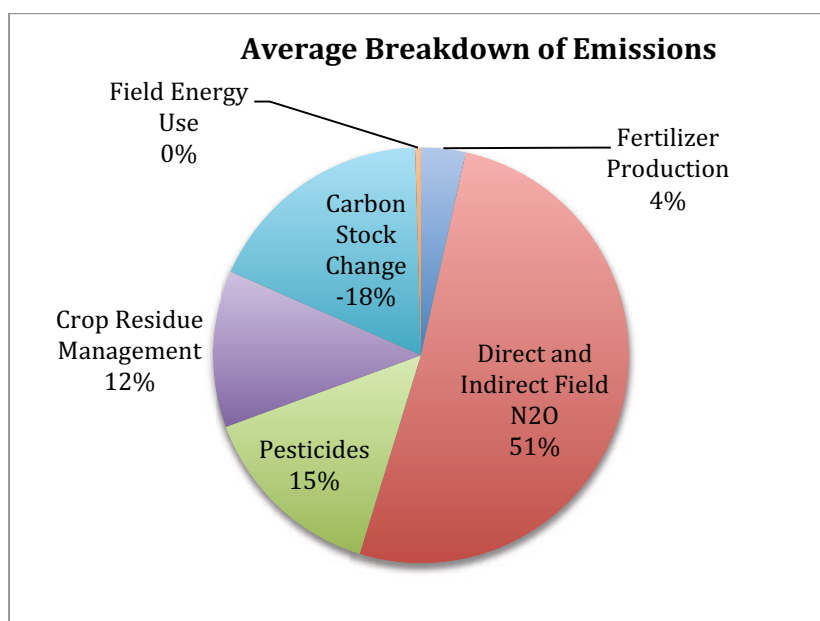
Yields varied widely between farms (between .13 and 2.26 tonnes/ ha). On a per tonne basis, emissions also varied significantly (from -71,274.6 to 7,991.6 kg CO₂e per tonne), with a median of 1,039.9 kg CO₂e/ tonne. Farm 'MHG' was a bit of an outlier in this context as well (as it was responsible for the -71,274.6 kg CO₂e/tonne of sequestration). If we remove this farm from this analysis, the new range of emissions is between -8,570.3 and 7,991.6 kg CO₂e when examined on a per tonne basis.

Breakdown of Emissions Factors

In order to get a sense of the different factors contributing to overall emissions within these farms, Figure 3 shows the average relative contribution of emissions factors on a **per ha basis**. In this analysis we keep the originally listed land use change from grassland to arable. To arrive at these percentages we averaged the emissions across each category for all farms.



Figure 3. Average Breakdown of Emissions (on a per ha basis)



The largest source of emissions is the direct and indirect field N₂O emissions, which is largely the result of fertilizer application. In the case of the Nicaraguan bean farmers sampled, all farmers that were using fertilizers were using synthetic fertilizers. When compared to organic fertilizers, synthetic fertilizers tend to have higher fertilizer production emissions and do not have a soil sequestration benefit associated with their application. A scenario comparing baseline synthetic fertilizer use to organic fertilizer use is detailed below in the ‘Reduction Scenarios’ section.

Pesticide use and emissions related to crop residue management also play an important role in the breakdown of emissions. Pesticide application rates were about 8 on average. Crop residues were handled in four different ways on the farms sampled and their emissions are detailed in a reduction scenario in the section below. There is a subset of farmers that left their residues on field and incorporated them, a practice which can sequester carbon in the soil (and offset overall emissions) but in order to determine the soil carbon sequestration impacts of this activity we need more information. We were unable to determine whether leaving the residues in the field has been an ongoing practice for these farmers or whether it is a new practice they have started utilizing within the last 20 years. Without this information we are unable to provide an estimate of the possible correlated soil carbon benefits.

Note on residue quantities: CRS did a separate analysis on the quantity of residue generated by bean production over a sample of farms during the Primera season. Their analysis revealed an average ratio of 1.04 bean weight to the residue weight. For each farm (across all seasons) we used this relationship in combination with the tonnes of beans produced and the size of each farm to calculate a residue figure in tonnes/ ha. In some cases this new value was identical to the value CRS provided in the CFT, in other cases there was a large difference. All residue quantities were calculated using this same method in order to ensure standardization of results in this analysis.

Carbon stock change (representing -18% of the emissions profile), comes from sequestration related to above ground biomass in trees on the farm, emissions from land use change (in this case there were seven farms that reported a change in land use from grassland to arable) and the



small percentage of sequestration related to residue incorporation from two farms for which we had duration-of-practice information.

Finally, field energy use emissions make up a negligible source of emissions for these farmers. Field energy use, which was a source of interest to CRS because they wanted to compare mechanized soil preparation to manual and animal techniques ended up not being a large source of emissions overall. Of the three farms that did include energy use from tractors, emissions related to that use were about 29 kg CO₂e. This amounts to about 4% of the 693.1 kg CO₂e average emissions.

Data concerns and accommodations related to carbon stock change:

Although our concern related to the accuracy of the land use change conversion is detailed above, tree diameter measurements is a second area where we have data concerns. These measurements were likely estimated for the last year. In most cases, trees were estimated to have grown 0.5 or 1 inches during the last year. In a couple of cases where trees had been reported as growing several inches during the last year, we changed the growth rate to 1 inch as field staff informed us that the large growth rates were likely an error. This growth rate assumption was applied across the board whether the trees were large or small and we do not know how representative this is of growth rates of trees of different sizes and ages. Having actual data on the growth rates of trees for both the current year and the previous year would remove large uncertainties from the estimates of carbon stock change in the above ground biomass.

Reduction Scenarios

Ultimately, the aim of this study was to gain an understanding of current emissions and the accessible and feasible emissions reduction pathways that help drive sustainable livelihoods for farmers and also contribute to climate change mitigation and adaptation. Below are scenarios of interest to CRS that examine organic fertilizer use, residue management, along with further discussion on trees and land use change.

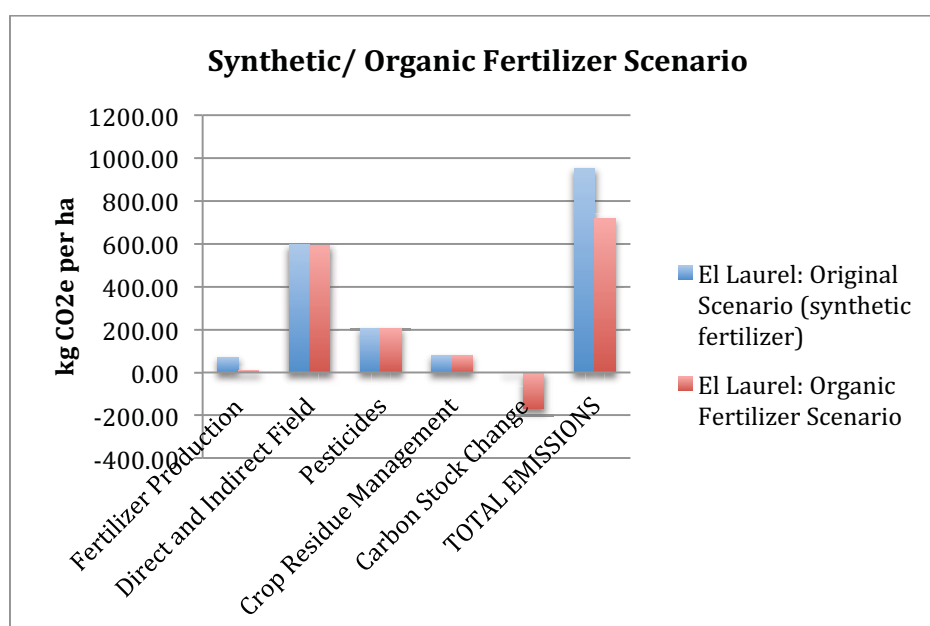
Organic Fertilizers:

To model replacing synthetic fertilizers with organic fertilizers, we chose one farm (El Laurel from season Apante) that had somewhat middle range fertilizer application rates (fertilizer application rates varied dramatically between farms, with some farms reporting extremely low fertilizer use and others substantially more). In the base scenario, El Laurel used two fertilizers, Compound NPK 11-20-15 at a rate of 64.7 kg of product/ha and foliar fertilizer at a rate of 10kg of product /ha. We modeled the result when this farm replaces their Compound NPK use with organic fertilizers (cattle farmyard manure) using the same rate of N application. This allowed us to see not only the emissions involved in the production of the fertilizer itself, but also let us account for the sequestration (carbon stock change) related to manure incorporation, a benefit that is not seen with synthetic fertilizers.

Figure 4 demonstrates this change. This switch in fertilizer types generated an emissions savings; while the baseline scenario has emissions of 951.8 kg CO₂e/ ha, the switch from Compound NPK to manure results in a scenario with emissions of 719.1 kg CO₂e/ha. The drop in fertilizer production emissions and the sequestration from carbon stock change can both be seen in the organic fertilizer scenario. Cattle farmyard manure is listed in the Cool Farm Tool as having zero production emissions due to the assumption that the emissions calculation from the production of cattle farmyard manure would fall within the scope of the milk or beef lifecycle analysis.

Figure 4. Organic Fertilizer Scenario





Before pursuing a switch to organic fertilizer use, farmers would need access to sufficient quantities of affordable and high quality compost/ manure.

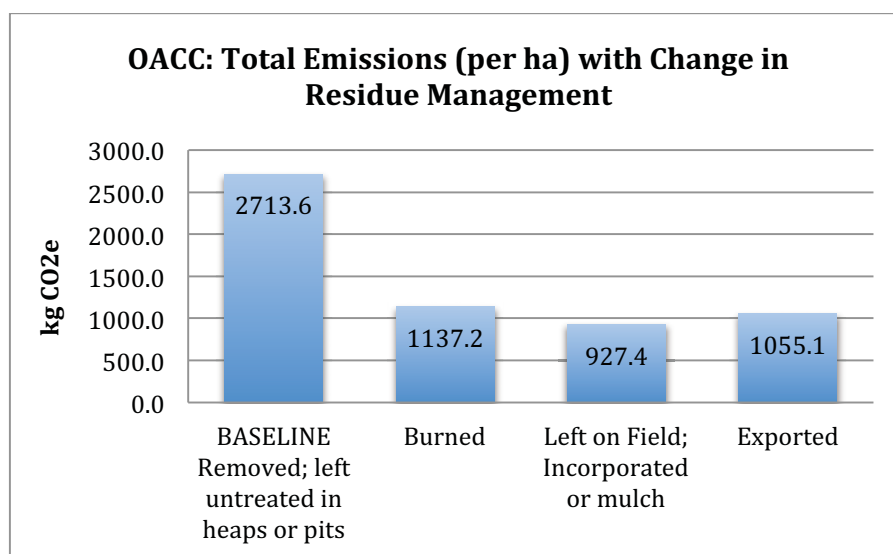
Residue Management:

Crop residue management is another area with emissions reduction potential. Currently, there are four separate ways that residues tend to be handled on these farms: 1) removed; left untreated in heaps and pits, 2) burned, 3) left on field; incorporated or mulch, 4) exported.

In order to show the emissions impact related to these different residue management techniques, we chose farm OACC (season Primera), which was the only farm that removed residues and left them untreated in heaps and pits (the most emitting practice). We ran all three additional management scenarios against this baseline using the same quantity of residues (0.93 tonnes/ha). Figure 5 shows the results of these scenario changes as they impact total emissions on this farm.



Figure 5. Residue Management Scenarios



This graph shows the baseline emissions for this farm when the residues are removed and left untreated in heaps and pits. When the residue management is changed to burning, the overall farm emissions drop by over half (related substantially to a drop in methane production). Exporting crop residue does not generate emissions affecting this farm, so this scenario emits about 82 kg CO₂e less than when residues are burned. When crop residue is left on field; incorporated or mulched, there is an increase in N₂O emissions from these residues but also an associated carbon sequestration benefit in the soil that can offset the emissions associated with the residue, creating an overall net decrease on the farm's emissions.

These scenarios highlight that there is significant opportunity for optimizing the practices associated with residue management on these farms, through training on possible alternatives, such as residue incorporation or composting. Helping farmers to adopt practices that will result in well-aerated decomposition will help to reduce the methane emissions.

Trees & Land Use Change:

Another significant result from this sampling of farms is the impact of trees within the bean cultivation area. In some parts of Nicaragua, farmers practice a traditional cultivation system known as 'quesungual', which incorporates agroforestry with traditional arable crop production as seen below.





Traditional cultivation system which incorporates agroforestry with crop production

Currently, there are 8 farms that reported trees within their bean cultivation area. This had a tremendous positive impact on these farms: increasing the above ground carbon sequestration and reducing overall emissions. The ability to plant more trees into these quesungual systems is a potential area of impact, especially if they are other income generating tree species (like fruits crops, for example).

Because this is a high potential activity, we ran an analysis to see how many trees would be needed to offset the average emissions from these farms (on a per ha basis). If a farmer planted tropical moist hardwood trees that grew from 3 to 4 inches in diameter during the last year, each tree would sequester about 20.7 kg CO₂e. Extrapolated out, that would mean that 34 trees per ha (of that same type and size) would be needed to offset the 693.1 total average emissions per ha. Of course, any other type or size of tree will dramatically impact this number.

Agriculture in Nicaragua is still extensive and farmers continue to bring new areas of land into production as the population increases. The ability of CRS and its partners to encourage sustainable intensification and good management of existing agricultural land will contribute to the prevention of further emissions from converting pasture or forest to arable crop production as well as other environmental benefits such as watershed protection and soil conservation. Mitigation of the land use change emissions can also be achieved through the promotion of reforestation on some of the land, either with agroforestry crops like fruit trees, coffee or cocoa or with valuable timber species.

Notes on the Cool Farm Tool

Upon completion of this assessment, the feedback on the Cool Farm Tool includes: the need to for a Spanish version of the tool, as well as detailed user guidance in Spanish. Given the diverse nature of many smallholders in CRS projects, there is also a need to develop an interface function to allow for the modeling of multiple crops throughout the year grown on one parcel and account for the diverse variables in these farms that would ease the modeling of these multiple crops' contribution to a whole farm carbon footprint. This added user-friendliness would help CRS model the effects of livestock and reforestation in offsetting emissions as farmers increase yields through intensification or input use.

