Kirkpatrick Model to Determine the Effectiveness of the NAMA´s Support Project Training Program on Good Agricultural Practices for Coffee Growers in Costa Rica

Abstract:

In 2013, Costa Rica created a Nationally Appropriate Mitigation Action, NAMA *Café de Costa Rica*, the first agricultural NAMA in the world. This study attempts to determine the effectiveness of the training program on Good Agricultural Practices (GAPs), implemented in seven Costa Rican coffee regions by NAMA Support Project, ICAFE and MAG, to generate awareness on climate change and to produce a low-carbon and sustainable coffee production. The Kirkpatrick Model was used to evaluate the effectiveness of the training program. Overall, the training methodology developed was highly accepted by participants. The program generated and reinforced awareness on coffee growers regarding the implication of climate change on coffee production and vice versa, also the program transferred knowledge on participants about the relevance of GAPs and its application in their farms. A high percentage of coffee producers is willing to shift to GAPs and a considerable percentage is already implementing them to their daily activities, what shows a change in the behavior of participants. The methodology generated could be reinforced, replicated and evaluated in other regions and agriculture systems, as well; it should be used as the basis and one of the pillars for the construction of a robust monitoring, reporting and verification system of GHG emissions of coffee production.

Key words: NAMA *Café de Costa Rica*, climate change, GAPs, coffee production, Kirckpatrick Model.

1 Introduction

Climate change is unequivocal and now can be firmly attributed to human activity (UNFCCC, 2011) and alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 1992). In December 2015 was negotiated and adopted the Paris Agreement during the 21st Conference of the Parties of the UNFCCC in Paris and signed in 2016; The Agreement aims to strengthen the global response to the threat of climate change by keeping a global temperature below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius, and to strengthen the ability of countries to deal with the impacts of climate change (UNFCCC, 2015). By 2017 195 of 197 parties have signed and 170 have ratified to the Convention (UNFCCC, 2017).

Costa Rica is among the signatory and ratified countries to the Convention with an absolute and unconditional emissions reduction target (Climate Action Tracker, 2017). Costa Rica reaffirmed its aspiration of becoming a Carbon Neutral economy starting year 2021, as a culmination of its voluntary, pre-2020 action under the Paris Agreement; the country had proposed to compensate its emissions through offsetting by the forest sector, as well is committed to a maximum of 9,37 Mt CO_{2eq} net emissions by 2030 (MINAE, 2015).

The Costa Rican government, the private sector and international partners collaborate to develop Nationally Appropriate Mitigation Actions (NAMAs). Due to extensive importance of coffee in Costa Rican economy, the first NAMA implemented was the NAMA *Café de Costa Rica* -since 2013-, to reduce the carbon footprint of the sector and maintain sustainable coffee production in the future (NAMA, 2017).

NAMA Café promotes specific actions to achieve a low-emission and sustainable coffee production, such as the efficient use of fertilizers and support of agroforestry systems in coffee. These actions can be reached by strengthening the technical and institutional capacities at country level (NAMA, 2017).

The main purpose of this study has been to determine the effectiveness of the training program on good agricultural practices and technological knowledge to generate awareness about climate change on coffee growers, using the Kirckpatrick method of evaluation. Additionally, this methodology is intended to generate experiences that can be replicated in other regions and agriculture systems, as well as, to serve as a basis towards the implementation of a robust monitoring, reporting and verification system (MRV), by linking field training and GAPs adoption, that would trigger the reduction of GHG emissions that need to be accounted accurately.

2 Literature Review

2.1 Economic impact of Coffee in Costa Rica

Agriculture plays an important role in the Costa Rican economy; in 2016 it represented 22% of total Costa Rican exports (INEC, 2017). During this year, the main agricultural products in the country export portfolio were banana, pineapple and coffee, representing 80,5% of total agricultural exports. Dry green coffee exports were ranked 3rd in terms of importance, accounting for 14% of total value of agricultural exports and 3,2% of the total exports of the country (SEPSA, 2016).

Coffee is the most extensive crop in Costa Rica, the cultivated area account for 84.133 hectares distributed in 23.527 farms (INEC, 2015), and about 45.445 producers (ICAFE, 2016). According to ICO (2017), in 2016 the worldwide coffee production reached 157,5 million bags (60 kg bags), 65% of which was Arabica coffee. Costa Rica was the 10th largest Arabica coffee producer, producing 1,32% of global Arabica production. World coffee production for 2017/2018 has been forecasted at 159 million bags according to USDA (2017).

2.2 Climate change and Agriculture

Agriculture, which depends directly on natural resources and climatic conditions, is affected more than any other sector by climate change; due to the increase of climate events such as heat waves, droughts and floods, changes in plant diseases and pest species, among other impacts (FAO, 2017). Nevertheless, agriculture is also a major source of anthropogenic greenhouse gas emissions, and directly contributes to approximately 10% - 12% of global greenhouse gas (GHG) emissions (Smith *et al*., 2014).

The cause of climate change is attributed to human expansion of greenhouse effect (IPCC, 2014). The gases that contribute to the greenhouse effect include water vapor (H_2O), carbon dioxide (CO_2 = GWP1), methane (CH_4 = GWP 28-36 over 100 years), nitrous oxide (N_2O = GWP 265-298 over 100 years), and chlorofluorocarbons (CFCs) (NASA, 2017). The Global Warming Potential (GWP) allow comparisons of the global warming impacts of different gases, the larger the GWP the more that gas warms the Earth compared to CO_2 over that period of time (EPA, 2017).

Agricultural activities in most soils that lead to an increase in available nitrogen (N) enhances nitrification and denitrification rates that then increase the production of N_2O (De Klein, *et al*., 2006). The increases in available N can occur through different sources, such as: synthetic N fertilizers, organic N applied as fertilizer, N mineralization associated with loss of soil organic matter resulting from change of land use, among others (Lamb *et al*., 2014).

Liming, used to reduce soil acidity, leads to CO_2 emissions as the carbonate limes dissolve (calcic limestone ($CaCO_3$), dolomite ($CaMg(CO_3)_2$) and release bicarbonate ($2HCO_3$), which evolves into CO_2 and water) (West and McBride, 2005). As well, using urea ($CO(NH_2)_2$) to fertilize soils leads to a loss of CO_2 fixed in the industrial production process (De Klein, *et al.*, 2006).

Organic waste material disposed from agricultural processes is biodegraded aerobic or anaerobically over a longer o shorter period. The main degradation products are CO_2, water and heat for the aerobic process and, methane (CH_4) and CO_2 for the anaerobic process (Jensen, *et al.*, 2006).

In 2012, Costa Rica released 12,15 Mt $CO_{2eq}{}^{-1}yr^{-1}$, and 2,72 t $CO_{2eq}{}^{-1}cap^{-1}yr^{-1}$ ranking 129 worldwide according to information provided by EDGAR (2017). Agriculture, Forestry, and Other Land Uses (AFOLU) produced 1,19 Mt $CO_2{}^{-1}$ yr^{-1} that represent around 10% of total emissions of Costa Rica (MINAE, 2012). Coffee production in Costa Rica produces 25% of total greenhouse gas emissions from agricultural sector (ICAFE, 2016), releasing 0,116 kg $CO_{2eq}{}^{-1}$ kg^{-1} green coffee (NAMA, 2016). The main sources of emissions in coffee production are the process of fertilization, decomposition of coffee pulp and the treatment of wastewater. According to MINAE (2012), coffee production produces around 39% of total N_2O released in agricultural soils, due to the use of N-based fertilizers.

2.3 Climate Change adaptation and mitigation on coffee production

Climate change affects agriculture and food production in complex ways (UN, 2009), due to the increase of temperature and precipitation variance; being the main challenges: physiological effects on crops quantity and quality, increase in weed and pest issues, changes in land, soil and water resources, decline in yield and production, fluctuations in world market prices, among others (FAO, 2007). These alterations in precipitation and other extreme weather events directly impact coffee production, specifically, quality and productivity levels (Coffee & Climate, 2015).

Adaptation along with mitigation is considered the key response to climate change. IPCC defines adaptation as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007). Mitigation refers to efforts to reduce or prevent emission of greenhouse gases. Mitigation can mean using new technologies, making production processes more efficient, using equipment more energy efficient, or changing management practices or consumer behavior (UN, 2017).

An effective adaptation to climate change or adaptive capacity can be enhanced by increasing the resources and knowledge of farmers, responding to climate change risks, for instance by training them on how to develop a more effective irrigation system, the efficient use of inputs and the use of good agricultural practices (Climate & Coffee, 2015).

Costa Rica is a leading country in the region, regarding climate change mitigation and adaptive efforts in the agricultural sector. In 2013, it was created the Nationally Appropriate Mitigation Action (NAMA *Café de Costa Rica*) for coffee sector, as a basis to reduce greenhouse gas emissions and generate experiences for other crops and sectors (Bouroncle *et al*., 2015).

The NAMA *Café de Costa Rica* is the first agricultural NAMA implemented worldwide. This is an effort to reduce GHG emissions and improve resources use efficiency at the level of both coffee plantations and coffee mills, by the efficient use of fertilizers, using water and energy in the coffee processing more efficiently, promoting financial mechanisms to support new agroforestry systems in coffee, among other actions. This program promotes the strengthening of technical and institutional capacity at country level, as well as the training of coffee growers and mill operators on agronomic and technological knowledge (NAMA, 2017).

2.4 The Roles of Local Actors on addressing Climate Change

According to UNCCC (2009), effective adaptation to climate change and mitigation of GHG take place through the dynamics of local governance, civil society engagement, and economic development from the actions of local authorities, civil society organizations, and private sector business.

Swanson *et al*., (2007) indicate that adaptation and resilience can be addressed most effectively by building communities' capacities to reduce their vulnerabilities. Colls *et al*., (2009) mentioned that by diversifying and adjusting ecosystem management practices, farmers could increase their resilience to climate change. Zuluaga, Labarta and Läderach (2015) determined that farmers who have received technical assistance or agricultural training and have perceived changes in temperature and precipitation frequency are more likely to implement at least one adaptation strategy to climate change.

2.5 Assessing the Effect of Training

According to Balkin, Cardy and Gómez (2008), training is defined as the process in which specific skills and knowledge are provided through a learning experience to an individual or a group, with the purpose of achieving effective performance in any activity. The goal of training is for trainees to acquire knowledge, improve skills, and behaviors emphasized in training programs and to apply them to their day-to-day activities (Noe *et al.*, 2000). Mitchel (1993) indicates that the particular function of training is to generate change.

Training has a high potential in transfer and utilization of latest technical know-how, leadership development, organization of people, mobilization of people and resources, and empowerment communities (Armstrong, 2000). People skills may be increased by learning how to perform new tasks, new methodologies or operate new equipment (Greer, 1995).

The evaluation is a systematic activity, integrated into the training process, to improve the process itself and to make a critical review of plans, programs, methods and resources employed (Fletcher, 1992) and to assess the effectiveness of the training program (Balkin, Cardy and Gomez, 2008), (Kirkpatrick, 1999). The reasons behind the evaluation of training are: to check the process of acquisition of knowledge by attendees, to detect current or potential issues on the training process, and to analyze the methodologies, resources, and activities used during the development of the training activities (Arazandi and Thomson, 2003).

Training can normally be evaluated with relevant, acknowledge criteria, being reaction, learning, behavior and results the traditional evaluative criteria, and in addition some researchers consider attitude as another category of evaluative criteria (Greer, 1995).

Kirkpatrick Model is the standard for evaluating the effectiveness of training, consisting in four levels: reaction (determine if training is favorable, engaging and relevant), learning (of intended knowledge), behavior (application of what learned during training) and results (if targeted outcomes occur as a result of the training) (Kirkpatrick, 2017).

Reaction criteria typically tap participants' satisfaction with training or their perceptions of its quality or relevance, student evaluations of professors are examples of reaction (Greer, 1995). The reaction of participants is evaluated to obtain information and suggestions on how to improve the training program (Kirkpatrick and Kirkpatrick, 2000).

Learning criteria are concerned with whether participants have absorbed the concepts or content of training (Greer, 1995). Through learning attendees change attitudes, broaden knowledge, and improve skills as a result of training.

Behavior criteria go a step beyond whether the trainee has learned the relevant concepts (Greer, 1995). These criteria are related to whether the training program has produced changes in the behavior of a trainee (Kirkpatrick, 1999). Results criteria can be defined as the degree to which targeted outcomes occur as a result of training and subsequent reinforcement (Kirkpatrick, 2015).

The evaluation of training is applied before, during and after training process (Kirkpatrick, 2017). Nevertheless, the real impact of what has been learned can only be measured and evaluated after some time has passed (Arazandi and Thomson, 2003). Therefore, the approach of this study is to determine the effectiveness of the program to generate awareness on coffee growers; hence, the impact of training in the adoption of GAPs should be assessed in an additional assessment.

3 Material and methods

3.1 Scope of the study

This study was conducted in seven Costa Rican coffee regions: Central Valley (San José, Heredia and Alajuela), Los Santos region (Dota, Desamparrados, Tarrazú, León Cortéz, Asserrí and Acosta), Turrialba, Brunca region (Coto Brus, Pérez Zeledón and Buenos Aires), Guanacaste region (Sarapiquí, San Carlos, Hojancha, Nicoya, Santa Cruz, Nandayure, Abangares and Tilarán) West Valley (San Ramón, Naranjo, Palmares and Grecia) and Orosi (Paraíso, Cachí, Ujarrás and Orosi).

The training program and the evaluation process were conducted from March to September 2017 at farm level, avoiding the harvest season, 3000 coffee growers from these seven regions were trained. It consisted in three modules and 27 workshops; 3 workshops in each region, and due to its large extension Los Santos and Brunca regions were divided in north and south.

3.2 Process design of the training program

The Costa Rican Coffee Institute (ICAFE), Ministry of Agriculture (MAG) and Deutsche *Gesellschaft für Internationale Zusammenarbeit* (GIZ) using design thinking methodology, carried several workshops to understand the way producers learn, and they used the outcomes to design the format and materials of the trainings, from this process the attributes of trainings were defined.

The trainings were held at the field in selected coffee farms, every module consisted in maximum four main topics, each topic took no more than 45 minutes, attendees were divided in no more than 30 people, the topics were selected taking into consideration the coffee production cycle and the time of the year when cultural activities were carried out, as well, the topics were facilitated using didactic dynamics and mini cases for management issues.

Under the NAMA *Café de Costa Rica* Support Project (financed by NAMA Facility and executed by GIZ); the Sustainable Markets Intelligence Center (CIMS) developed the materials used in the modules and workshops. ICAFE and MAG technicians from every region carried out most of the trainings. Experts of the Center for Tropical Agricultural Research and Education (CATIE) facilitated agroforestry and crops diversification workshops, and CIMS worked with climate change and farm management workshops.

The training topics were the following: Module 1: climate change and coffee, soil analysis, pruning and discarding, and irrigation. Module 2: nutrition and fertilization, weed management, plagues and diseases, and agroforestry systems. Module 3: farm management, coffee varieties, diversification of coffee farms, and soil conservation and management.

3.3 Evaluation methodology

Using the Kirkpatrick method, CIMS developed a survey to assess the effectiveness of the training program facilitated to coffee producers in the different Costa Rican coffee regions. The survey included the reaction, learning, behavior and results criteria in the questions made.

Once each of the third training module workshops finished, the team in charge of the evaluation process in every coffee region selected randomly a representative number of producers who have attended the training.

Around three thousand coffee growers participated in the different workshops in the seven coffee regions, which were selected by ICAFE, MAG and coffee mills representatives. Depending on the region some workshops were more crowded than others, from 25 to 120 attendees per workshop. The sample size was 219 coffee producers.

The population assessed consisted in 82% male and 18% female, 67% were between 41 and 70 years old, 69% possessed a farm with an area of 5 ha or less. 49% attended the three modules, 25% participated in two of the modules and 26% were in one of the three modules.

3.3.1 Reaction Criteria

To evaluate the reaction criteria regarding the training program, it was asked attendees to rank, using a quality rating scale, the quality of materials used in the workshops, the training duration time and schedules, if they have applied what learned during workshops in their daily fieldwork, if the materials used were interesting and easy to understand, if the place was appropriate, and the quality of the topics facilitated.

3.3.2 Learning Criteria

A pretest-posttest was used to assess the knowledge criteria; participants were asked to rank, using an agree-disagree rating scale, a question set regarding their knowledge about good agricultural practices, before and after the training program.

The questions asked were about the different workshop topics; if producers acknowledged the need to reduce GHG at farm and country level, as well as, if they knew the options to reduce GHG at farm level by the efficient use of agrochemicals, especially nitrogen-based fertilizers. Also, if producers could explain others how important are to plant trees to capture and storage carbon, and if they understand in which conditions a coffee plantation requires shade (trees).

Coffee producers were also asked about their knowledge regarding the importance of a good soil management, and if they could explain how a good management of their coffee plantation (varieties, shade, fertilizers) reduce unnecessary costs and avoid environmental impacts. Also, if they knew the importance of a weed management, pruning appropriately, a soil analysis, and the triple rinse of pesticide containers.

As well, producers were asked if they could interpret a soil analysis, could explain how to do a pest sampling, acknowledged the importance to fertilize based on the coffee needs, and if they could do a equipment calibration adequately.

3.3.3 Behavior Criteria

To assess the behavior criteria regarding the training program, it was asked participants to rank, using a behavior rating scale, about how encouraged are they to make changes in their agricultural practices learned in the workshops, and if they are applying the knowledge and practices learned in their daily activities.

4 Results

4.1 Reaction of Costa Rican Coffee Producers to the Training Program

Regarding the quality of materials used in the workshops, almost all participants were satisfied with the quality of materials; 70% said excellent and 29% fairly good. According to 90% of participants, the training time and schedules were appropriate; 54% ranked it excellent and 36% fairly good. 98% of the coffee growers found interesting and easy to understand the materials used; 71% indicated that the materials presentation was excellent and 27% fairly good. 96% reacted positively to the fact that training was carried out in the field; 73% said excellent and 23% fairly good. And, 98% of participants mentioned that the workshop topics were appropriate; 77% said excellent and 21% fairly good.

Overall, this indicates that attendees from the different Costa Rican coffee regions reacted positively and were highly satisfied with the training program (Figure 1).

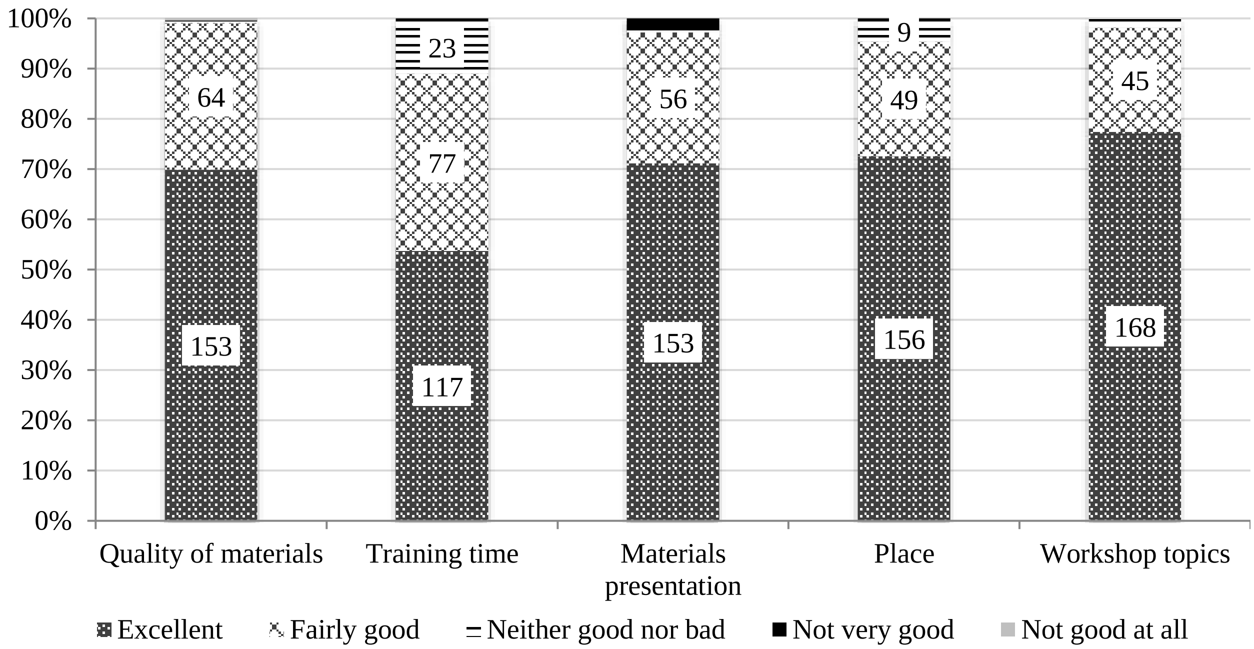

Figure 1. Reaction of coffee producers from seven different Costa Rican coffee regions to a training program.

4.2 Learning Criteria Assessment on the Training Program

The main findings regarding Learning Criteria are presented in Table 1. Overall, after the training, there was an increase of the awareness about the importance of GAPs application and climate change relevance in coffee production. These results are discussed in detail in the following section.

Producers acknowledged the need to reduce GHG at farm and country level, after the trainings 94% of them were aware about it, even though 62% of producers assessed said they knew before the trainings that GHG needed to be reduced. The training reinforced the awareness of producers that already knew this topic, and generated awareness on 32% of producers that did not acknowledge the need to reduce GHG before the training.

Participants after the training (94%) said to know what options they have to reduce GHG at farm level, especially the reduction of nitrogen-based fertilizers and other agrochemical applications. Before the training, 60% of coffee producers had knowledge about the options to reduce GHG, what means that after the trainings 34% more participants knew about these options.

After the training program, 95% of coffee growers can explain others how important is to plant trees to capture and storage carbon, 26% more than before the training. As well, 97% of participants understand in which conditions a coffee plantation requires shade, 35% more than before the workshop regarding shade management.

Producers (96%) agreed that it is important a good soil management, 28% more producers than before training (68%) who already have had information about the topic. 96% of coffee growers understand that an appropriate management of their coffee plantation; using resistant varieties, managing shade and using fertilizers according to the needs of the coffee plantations, can reduce the cost and the environmental impacts, 46% more than before.

As well, 95% of participants learned about an appropriate weed management, 35% more than before the workshop about this topic. 96% of respondents know how to prune according to the plantation needs, 32% more than before.

96% of producers said that they understand the importance of doing a soil analysis, and 78% can interpret a soil test report, 27% and 39% respectively more than before the workshop on this topic. 96% of respondents indicated that it is important to fertilize according to the coffee plantation needs, 33% more than before the training.

The respondents (84%) also indicated that they understand and can explain how to do a pest sampling before the application of any pesticide, with an increase of 44% compared to before the workshop on this topic. Also, 85% of producers could explain and knew how to calibrate adequately the equipment to spray the pesticides, before the training only 47% knew about the topic. After the training, 90% of respondents knew the importance of the triple rinse of pesticide containers, 67% had the knowledge before the training.

Therefore, from the information presented in Table 1 and previously exposed in this section, it can be inferred that the training program raised awareness on coffee growers (see difference between post-training and pre-training in Table 1), regarding climate change and its implication on coffee production, as well as the impact of coffee on climate. Also, the program transferred knowledge on these producers about the importance of GAPs and its timely application depending on the coffee production cycle. Besides, the trainings reinforced the awareness and the knowledge on participants who said they already have had information about the topics discussed before (pre-training).

Table 1. Learning criteria assessment on the training program using a pretest-posttest.

Question set of knowledge criteria regarding the training program	Pre-training	Post-training	Difference
Acknowledge the need to reduce GHG	62%	94%	32%
Options to reduce GHG (farm level)	60%	94%	34%
Can explain importance of trees as carbon sequesters	69%	95%	26%
Importance of shade on coffee plantation	62%	97%	35%
Importance of soil management	68%	96%	28%
Farm management as cost and environmental impacts reducer	50%	96%	**46%**
Importance of weed management	60%	95%	35%
Pruning	64%	96%	32%
Importance of soil analysis	69%	96%	27%
Importance of triple rinse pesticide containers	67%	90%	23%
Interpretation of soil analysis	39%	78%	39%
Pest sampling	40%	84%	**44%**
Fertilization based coffee needs	63%	96%	33%
Equipment calibration	47%	85%	38%

Figure 2 shows the results of the Learning criteria assessment on the training program per number of modules attended. After the trainings, there was an increase in the number of participants that acknowledged the importance of good agricultural practices and its application, and its role to reduce GHG at farm level.

After the training program, in average 93% of participants who attended the three modules were aware about the topics facilitated in the different workshops of these modules, and about the relevance of climate change on coffee production and vice versa. In average 77% and 78% of producers who attended 1 and 2 modules respectively mentioned that they were aware about the topics facilitated in these modules, which represent 15% less than producers who attended the three modules.

The program reinforced the knowledge and awareness of coffee growers that already had information about these topics before the trainings, 47%, 56% and 58% of attendees of one, two and three modules respectively. Therefore, the training program generated awareness on 36% of producers who attended the three modules, which is slightly higher than producers who attended one or two modules (30% and 22% respectively).

It is important to note from the results presented in this section that the percentage of coffee growers, who were aware and got knowledge about the different topics facilitated, was higher among who completed the training program, attending to the three modules, than among who attended one or two modules. Hence the importance to complete and participate in the whole training program.

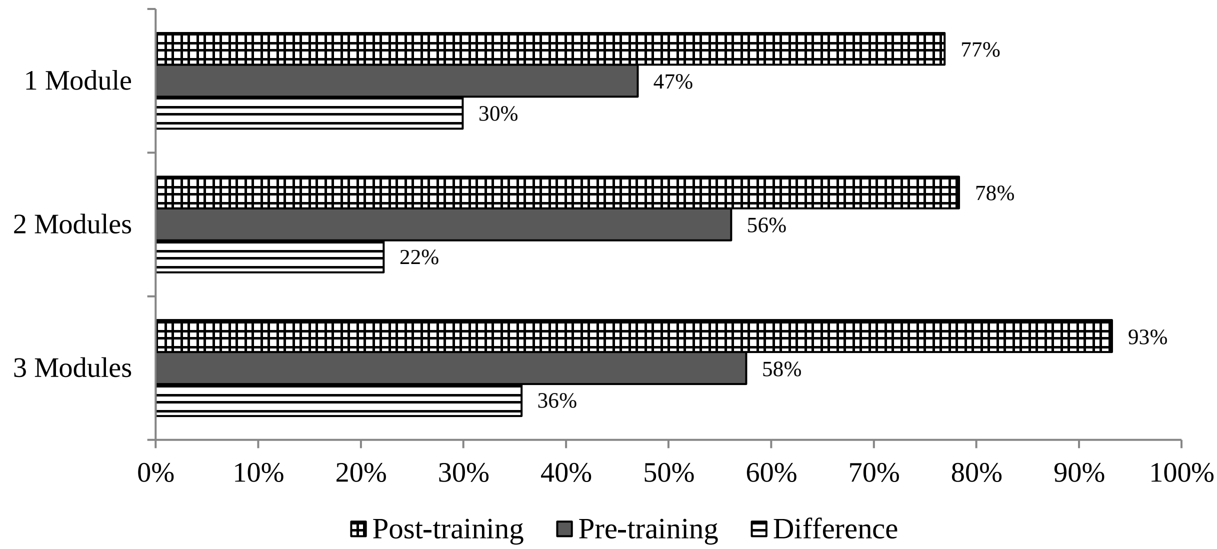

Figure 2. Learning criteria assessment on the training program using a pretest-posttest, per modules attended.

4.3 Behavior Criteria of Costa Rican Coffee Producers on the Training Program

After the training program, producers are willing to improve their agricultural practices and apply the good agricultural practices they learned from the workshops. The average percentage of producers who want to shift to GAPs is almost 99%; 81% of them are very encouraged and 18% are encouraged to make these changes. This behavior is trend along the regions, age and the number of modules attended (Figure 3).

This indicates that the training program yielded a change in the behavior of almost all participants who attended the workshops, due to their willingness to incorporate the GAPs learned in the trainings into their daily activities.

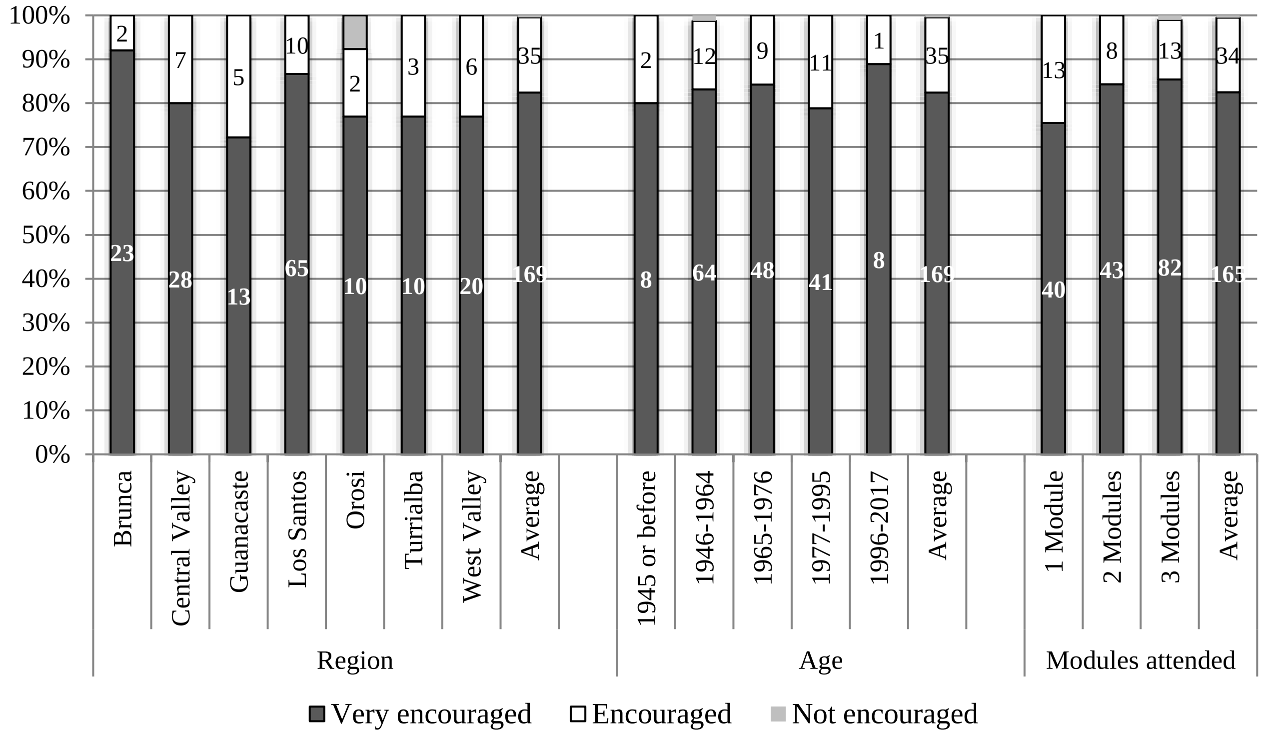

Figure 3. Behavior of coffee producers to shift to good agricultural practices, by region, age and modules attended.

From the participants who mentioned they were willing to apply changes in their agricultural practices, about 85% already started to shift to some of the good agricultural practices learned from the training program, and apply them to their daily activities, considering the coffee production cycle. Guanacaste, Orosi and Turrialba are the regions where the adoption of GAPs seems to be slightly less compared to the other regions. Classifying producers by age and the number of modules attended, the behavior is similar and there are no big variations; around 90% of coffee growers are applying in some extent the knowledge obtained from the workshops, except for the youngest producers who are over the average and seem to be more willing to change their behavior, taking into consideration that these practices are carried out at different times of the year (Figure 4).

Therefore, these results suggest a change in behavior of participants who attended the program and were willing to implement changes in their farm by adopting the GAPs learned.

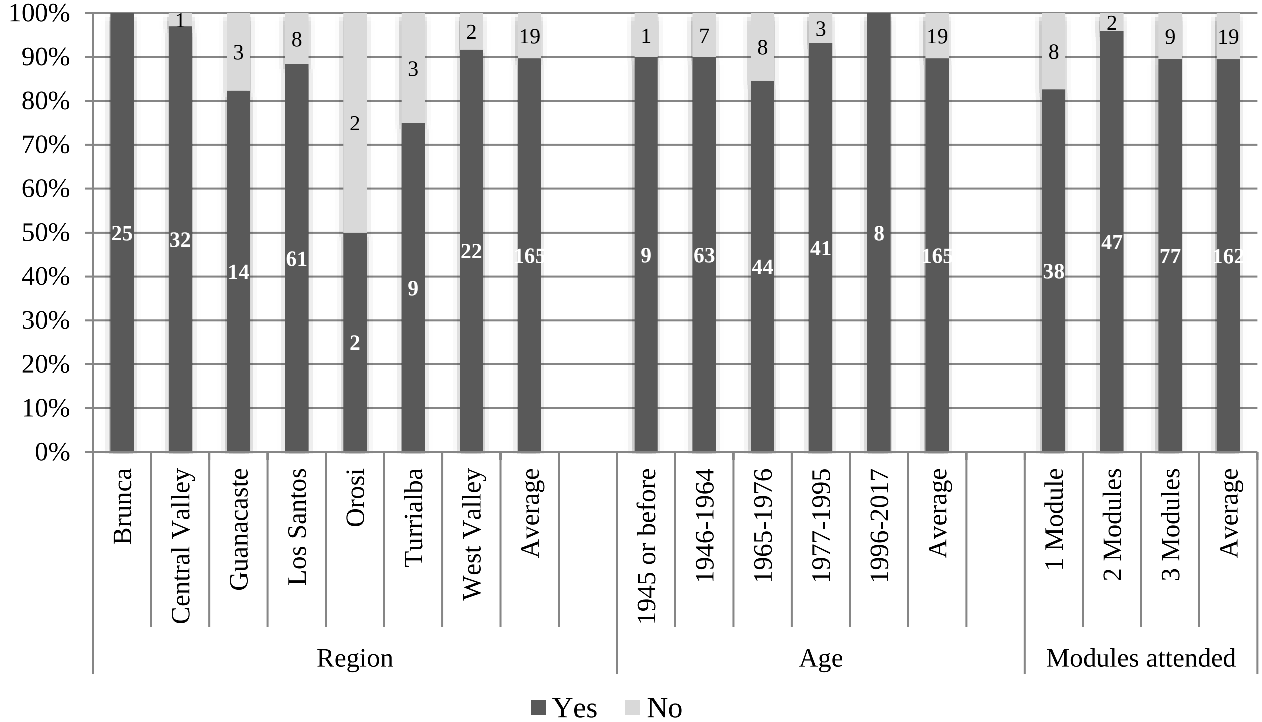

Figure 4. Behavior of coffee producers to apply good agricultural practices, by region, age and modules attended.

5 Discussion

To address climate change and adapt coffee cultivation to it, the different stakeholders involved in the coffee production should work together and establish mechanisms to reduce and manage the GHG emissions. NAMA café de Costa Rica promotes the use of Good Agricultural Practices (GAPs) at farm level to improve producers' management practices through three training modules; these measures aim to reduce greenhouse gas emissions in the process of coffee production.

The results of the training evaluation (see Table 1) suggest that coffee producers are now more aware about the implication of climate change on their farm, as well as the impact of coffee production on the environment. The workshop attendees also mentioned that they recognize the importance of shade trees as carbon storage and as an important part of the coffee production system as temperature and humidity regulator. Thus, the NAMA support project should take into consideration the contribution of agroforestry systems as carbon storage and as providers of other co-benefits in coffee production, which are coherent with the principles of adaptation to climate change.

The application of fertilizers is a main contributor of GHG emissions in agriculture, due to the release of N_2O in the process of nitrification and denitrification of N-based synthetic fertilizers (IPCC, 2006). Coffee producers indicated that now they acknowledge that the optimization of the application of fertilizers is highly important; from the workshops the producers learned the basics of how to sample, analyze their soil and the principle to interpret the results to identify the nutritional requirements of their crop, and then apply fertilizers accordingly.

The variability of temperature derived from Climate change affect and make pest, diseases and weed more resistant (Ameden and Just, 2001); according to the learning criteria used in the evaluation process, it was established that participants can monitor and control them more effectively; these actions also represents opportunities to adapt coffee production to climate change.

An efficient farm and crop management and the application of the GAPs could also lead to potential cost savings and environmental benefits; for instance the application of fertilizers based on the crop needs and soil analysis. The study suggested that after the training, producers were more aware about these cost-benefits of managing appropriately their farm, therefore the training program should also include and deepen in additional administrative and managerial workshops, to both make their farm more efficient and to adapt to climate change.

The results of this evaluation reveal that there is a change in the behavior of participants; they are after the training program willing to shift to GAPs learned from the different workshops, and also indicated that in some extent they are already making changes in the management of their coffee plantation, taking into account the coffee production cycle (see Figures 3 and 4). After a time has passed these changes could lead to a reduction of GHG emissions, if coffee growers in fact put them into practice, and that should be evaluated *a posteriori* in an additional assessment.

According to Vandenberg (2009), adult learners are busy, practical and learn by doing; they learn when there is immediate application for the learning, they participate actively in the learning process, and they can practice new skills or test new knowledge before leaving a learning session. The methodology and materials used to prepare and carry out the workshops in coffee farms, with a specific time, using interesting an easy to understand materials, and selecting relevant topics that have repercussions on coffee and climate, were highly accepted by almost all coffee producers. Coffee growers assessed are 67% between 40 and 70 years old and 28% between 40 and 20 years old, however the younger generation are slightly above average regarding the willingness to change and apply the GAPs learned from the workshops.

The training methodology used was not only well rated (see Figure 1) but also was efficient to deliver the scientific and technical knowledge to participants (see Table 1), as discussed before, due to the awareness generated and the change of behavior on coffee producers (see Figures 3 and 4). Nevertheless, this training methodology should be reinforced and deepen especially in coffee growing regions such as Guanacaste, Orosi and Turrialba, which show relatively higher climate change vulnerability (Barouncle *et al.*, 2015), and where the adoption of GAPs is lower than in the other regions. So, this methodology could be reinforced, deepen, replicated and evaluated in other regions and agriculture systems to address climate change.

6 Conclusions

The training program in the application of Good Agricultural Practices (GAPs) implemented under the NAMA Café de Costa Rica had a positive reaction, learning and behavior (criteria assessed in this study) impact on coffee growers from seven Costa Rican coffee regions. Overall, as shown in Figure 1, the producers reacted positively to the methodology used in the workshops; rating highly the quality of materials, which according to producers was friendly and easy to understand. The training time of no more than 45 minutes per topic and four topics per module seems to be appropriate, likewise the places selected (coffee farms) to carry out the training was adequate to develop the workshops, according to the adult learning theory. The topics of the workshops were developed considering the coffee production cycle and the needs of the coffee growers. Hence producers rated it satisfactorily (see Figure 1).

It was determined that the training generated awareness on the workshop attendees regarding the need of GHG reduction at farm level, especially the reduction of nitrogen-based fertilizers and the importance of trees to capture and storage carbon. As well, the training reinforced the knowledge of coffee producers about good agricultural practices on soil management, the importance of a soil analysis and the basics of the interpretation of a soil test report, therefore a fertilization based on that soil analysis. Also, coffee producers acknowledged the importance of an appropriate management of their coffee plantation; using resistant varieties, shade, weed management, pest sampling, among other good practices, to reduce costs and environmental impacts (see Table 1).

Coffee producers who participated in the workshops are highly willing to implement and already implementing in some extent the good agricultural practices learned, as presented in Figure 3 and 4. Therefore, the training generated a change in the behavior of coffee growers in the different Costa Rican regions. These changes should contribute to address the impact of climate change on coffee production and vice versa, considering that agriculture and coffee production are important contributors to GHG emissions in Costa Rica. Nevertheless, there is work to do with those producers; those high rates of awareness and willingness are part of a momentum that expresses compromise and motivation, this will not necessary last. So, the project and the institutions involved have to plan accordingly to capitalize real field results.

The Kirkpatrick Model of evaluation, and the analysis of the reaction, learning and behavior criteria, was key to determine the initial effectiveness of the training model to generate and reinforce awareness on coffee growers. Results criteria were not assessed in this study due to coffee production cycle constraints, therefore, additional assessment should be conducted to determine the real impact of training on increasing adaptive capacity and mitigation to climate change, which could lead to a reduction of Costa Rican coffee production carbon footprint.

Therefore, the training methodology and the workshops developed represent a useful tool to complement the empirical knowledge of coffee producers with scientific and technical proven good agricultural practices, which can be applied in a simple way by producers in their daily activities. As well, since they were part of the training methodology, the monitoring process should definitely assess the way the producers are using the take away printed material (leaflets) that the project handed them out, so they can consult them while in the field.

Furthermore, the methodology should be reinforced and deepen especially in regions with vulnerability to climate change (like Guanacaste, Orosi and Turrialba) and within older generations, which are below average regarding the intention to adopt the GAPs compared to the other regions. Besides, the program should motivate participants to attend all training sessions; the awareness on attendees of three modules was higher than in those who attended one or two modules. These regions, age range and the number of modules attended should definitely be taken into account in the subsequent training planning process of the project, as well as in the necessary follow-up within the verification process of the GAPs adoption. Likewise, this methodology can be replicated and evaluated with other producers in other regions and agriculture systems to contribute to an effective management of carbon emitted by a specific system.

Besides, the tool used as the basis of the exercise described in this study and its results, should be taken as one of the pillars for the construction of a robust monitoring, report and verification (MRV) system, that track and monitor consistently and reliably the contribution of the training program and any other teaching activity -which generate behavioral changes- to tangible goals of GHG emissions reduction.

For the purpose of strengthening an MRV, the correction of the application of the proposed model must be accompanied by scientific research, to determine effectively the contribution of the adoption of GAPs, taught in the training sessions to producers, in the reduction of GHG. As well, the monitoring process of the MRV should take into consideration that the Results Criteria -degree to which targeted outcomes occur as result of training- need to be evaluated in an additional assessment to complete the cycle of the Kirkpatrick Model proposed in this study, at least after a coffee production cycle, when coffee growers have had the opportunity to apply the changes into their farm, since the real impact of training can only be measured after some time has passed.

Thus, behavioral information, the subsequent adoption and change measures help to establish that a program such as the NAMA Support Project achieve the goals set at the sectorial level to reduce GHG emissions and to achieve a low-emission and sustainable production, that also contributes to the Costa Rican aspiration of becoming a Carbon Neutral economy and as a response to the country's binding commitment generated by the ratification of the Paris Agreement.

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