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Sustainable Territories Adapted to the Climate: Insights from a New University Course Designed and Delivered in Guatemala

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Abstract: Since 2014, the CGIAR research program on Climate Change, Agriculture and Food Security has collaborated with different stakeholders to implement climate change adaptation approaches and practices in critical locations in the Central American Dry Corridor. A new university course for professionals in the Dry Corridor aims to scale these approaches and practices. This article presents the core elements of the course, summarizes the main results, and offers recommendations for future editions. It was observed that the different trajectories and experiences of professionals facilitated a lively exchange of knowledge, the integration of local experiences in teaching, and the integration of learning in follow up proposals of governmental and non-governmental organizations. The following aspects should be central in future course editions: diversity of participants, adaptation of didactic strategies to the needs of different users, and follow-up to support, as well as the integration of course concepts and practices in the actions of different organizations. The latter requires strong organizational commitment.

Keywords: climate change adaptation; climate-smart agriculture; Guatemala; scaling; university course development

1. Introduction

Guatemala is one of the most vulnerable countries to climate change in Latin America. Part of the country belongs to the so-called Central American Dry Corridor, a region increasingly affected by summer drought, which is becoming more severe—starting earlier, lasting longer and with more intense heat. The cyclical summer drought coincides with a critical phase in agricultural production. These and other processes of climate change are having a serious impact on the livelihoods of people in the Dry Corridor, estimated to be about 10.6 million across Central America, causing hunger, health problems and poverty. Agriculture production and the main sources of food (maize and common bean) have suffered; income generation opportunities have decreased (sale of family labor for the cultivation of coffee in the winter season, sale of vegetables and fruits); and, as a result, migration has increased significantly [1–3]. Lack of access to adequate and timely weather and climate (change) information, such as seasonal forecasts, is one of the main bottlenecks impeding the management of disasters, a situation that many initiatives in the region have sought to improve in the last decade, with varying degrees of success [4]. This bottleneck is caused by the limited capacities of regional and national institutions to function effectively, coordinate their efforts, and reach out to citizens in cities and rural areas.

The CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) has collaborated since 2014 with Latin American academic organizations, local and national governments, non-government organizations, and farmer organizations to implement an approach known as sustainable territories adapted to climate change (in Spanish, Territorios Sostenibles Adaptados al Clima or TeSAC). The approach aims to promote innovative climate-smart agricultural knowledge, practices and services through a participatory, multi-stakeholder and multi-scale research for development approach. Activities include the conservation and sustainable use of agrobiodiversity, participatory variety selection with farmers, agricultural diversification, establishment of local weather stations and regional climate information hubs, piloting new crop insurance schemes, and climate-change related policy analysis and advice. Given the critical situation in Guatemala, the Dry Corridor region in this country has received priority on the CCAFS agenda for Latin America.

Agriculture in the Dry Corridor is characterized by smallholder farmers cultivating basic grains combined with cash crops such as banana and coffee in the hills and mountains, and larger scale commercial, export-oriented operations in the valleys (fruits and vegetables). At least 73% of Guatemala´s municipalities are located within the Dry Corridor [5], including most of the area of the Chiquimula and Jutiapa departments on the border with El Salvador and Honduras. These two countries also have a significant proportion of their municipalities within the Central American Dry Corridor (nearly 100% and 80%, respectively) [5]. The Central American Dry Corridor overlaps with the Trifinio Region, a territory that encompasses 45 municipalities of El Salvador, Guatemala, and Honduras. Since 1997, these three countries have maintained a cross-border collaborative process under the umbrella of the so-called Plan Trifinio. An interstate agency, the Territorial Office of the Trifinio Plan, works with stakeholders of different levels and promotes programs and projects for the sustainable development of the region, with a strong focus on water resources management [6].

The CCAFS research program in Latin America started in 2013 [7]; planning and *ex ante* cost/benefit analysis of climate-smart agriculture interventions for Guatemala took place in 2014 [8], and local (field) activities began in 2015. An important area of research took place at the community level through participatory research on climate-smart technologies and practices in one designated climate-smart village (CSV), similar to what CCAFS has been supporting in other regions of the world. In the climate-smart village, farmers are engaged, individually and collectively, in participatory variety selection, diversifying the production system, collective vegetable production, producing organic fertilizer, testing more efficient cooking stoves and rainwater collection devices, making use of agro-climate information, contract farming, and becoming familiar with new finance mechanisms [9]. Another complementary CCAFS research project concerned macro-level policy issues such as the identification of priority actions for adaptation in Guatemala's agricultural sector [10,11].

As part of the CCAFS strategy in Latin America, an alliance with the academic world for the training of human resources is key to scale concepts and practices of climate-smart agriculture and adaptation to climate change. Among the key academic organizations in the region, the University Center East (CUNORI) of the University of San Carlos of Guatemala, located in the city of Chiquimula, stands out. CUNORI analyzes and disseminates adaption concepts, practices, and technologies in collaboration with governmental and non-governmental entities across different careers, as well as postgraduate and diploma (*diplomado*) courses. The latter are short courses designed for professionals. In particular, CUNORI has implemented different short university training programs that combine face-to-face and virtual teaching/learning sessions to introduce, discuss and deepen key concepts, practices and technologies in the framework of the experiences of participating professionals.

In 2019, CUNORI, CCAFS and the Alliance of Bioversity International and CIAT developed and delivered a new diploma course about sustainable territories adapted to climate change, with the objective of strengthening the technical capacity of human resources in the Dry Corridor, with a focus on the Guatemala Dry Corridor and the Trifinio Region [12]. The course builds on and complements other CCAFS-supported activities in Latin America and Guatemala in particular [13].

Here, we present the course proposal, key course concepts, and results and lessons learned from the first version of the course delivered in 2019.

2. Course Objectives, Methods and Modules

2.1. Objectives and Methods

The course objective was to strengthen the capacity of professionals as agents of change, capable of designing and managing proposals that contribute to the adaptation to climate change experienced by the people of the Trifinio Region. The course aimed to strengthen four capacities: 1) knowledge about the factors that define vulnerability to climate change in the region; 2) knowledge about practices and technologies for adapting to climate change most relevant to the region (e.g. the sustainable use of agrobiodiversity), including the management of climate information; 3) ability to coordinate actions that allow the dissemination and scaling of adaptation practices and technologies; 4) ability to work in multidisciplinary teams for the management of programs and projects that favor adaptation actions to climate change, particularly in territories with the most vulnerable communities and families [14].

The university course was organized in four modules, each with a number of key topics. In the two first modules, climate change and climate change adaptation concepts, practices and technologies were prioritized (building on insights from agroecology), including climate information management. The last two modules focused on the concept and practice of scaling, as well as concepts and instruments to apply what was learned in the course regarding the design of adaptation projects in the context of the Dry Corridor. Thus, the module sequence moved from more conceptual to more practical elements. The detailed course program is presented in Annex A (Table A1).

Each of the modules consisted of a series of online assignments, e.g. reading, essay writing, and identification of key themes for group work, which were carried out individually and in groups. They also included three days of face-to-face teaching at the CUNORI campus. For the online work, CUNORI makes use of a dedicated, interactive teaching platform. During the face-to-face teaching days, the following were combined: conceptual presentations by subject experts (elements of theory, concepts, frameworks, indicators), presentations of practical experiences from Guatemala and Latin America, and discussion sessions (one in the form of a debate in plenary) between instructors and participants, as well as solely among participants. Fifteen representatives from one intergovernmental, six governmental, and three non-governmental organizations active in the Trifinio Region collaborated through presentations and interactions with participants. A complete list of these organizations is provided in the course handbook [14].

The course used the basic premises and insights of participatory action research and learning [15,16], encouraging participants to reflect critically on their own knowledge and practices and ask questions such as: What are we currently doing? Do we need to make changes so that our actions contribute more effectively to adaptation to climate change in the region? If so, what do we have to do differently and how? The face-to-face sessions also included group work sessions to integrate experiences and the new knowledge acquired in practical course exercises (i.e. a focus on praxis). These exercises all focused on real life and work situations (an example of a module 3 exercise is given in Table 1).

Table 1. Example of exercise: module 3, preparatory task 2: mini-essay.

Step	Content
1	Based on the readings (task 1 of module 3), write a one-page mini-essay (max 500 words) answering two questions: a) Based on your current or past professional activities, what knowledge, practice, technology, instrument or mechanism do you consider successful for adaptation to climate change, and why [just choose one example]? b) How would I scale it? Suggested essay structure:

	• A paragraph about your professional activity. • Description of successful knowledge, practice, technology, instrument, or mechanism. • How was it introduced? What resources were used? • Explanation of success: for whom? What has been the impact? How has it been measured? • What potential is there to scale it? How is the potential estimated? • How would you go about scaling it? What type(s) of scaling is (are) proposed?
2	Post your essay on the platform not later than November 8.
3	It is recommended to read some of the other essays (not all).

2.2. Modules

1. Practices and technologies for adaptation to climate change in the Dry Corridor of Guatemala: systematization of experiences and selection criteria for their implementation.

    - Climate change and its main impacts on rural livelihoods.
    - The territorial approach for adaptation to climate change.
    - Adaptation practices and technologies based on agrobiodiversity conservation, agroecology and sustainable management of crops, livestock, trees, water and soil: theory and results of their application (with examples from Latin America).
    - Experiences in capacity building and stakeholder organization.
    - Decisions on the prioritization of practices and technologies and their adaptation to local conditions.

This module introduced research supported by CCAFS in different parts of the world on how climate-smart technologies, practices and information can address the challenge of transitioning to climate-smart agriculture on a large scale under the new realities of climate change. The module presents the climate-smart village approach (first outlined in 2011), which includes [17]:

- Understanding the effectiveness of a variety of climate-smart agriculture options (practices, technologies, services, programs, and policies), not only to enhance productivity and raise incomes, but also to build climate resilience, increase adaptive capacity, and wherever possible, reduce Green House Gas emissions. In Central America, CCAFS is experimenting with an ICT devise, GeoFarmer, to collect data at household level and monitor the results of CCAFS interventions in order to document and analyze the results of the options introduced.
- Developing (no regrets) solutions in anticipation of future climate change impacts.
- Understanding the socioeconomic, gender, and biophysical constraints and enablers for adoption.
- Testing and identifying successful adoption incentives, finance opportunities, institutional arrangements, and scaling out/up mechanisms while ensuring alignment with local and national knowledge, institutions, and development plans.

In the climate-smart village approach, a 'village' could also be an agroecologically defined area, e.g., a small watershed. In Spanish, the word 'territorio' (territory) is used in the concept of territorio sostenible adaptado al clima (TeSAC), literally, climate-adapted sustainable territory, which was used for the course name. The spatial difference between village and territory is important. Originally, the approach focused on practices and technologies related mainly to crops and sometimes trees (in a village). The territorial approach is more holistic and agroecosystem-based. It focuses on a larger geographic area and considers the diversity of natural resource uses, the maintenance of ecosystem services, and the importance of collective action, e.g. the roles of farmer organizations [18,19]. It pays some attention to socio-economic and political dimensions, but the module does not engage with political ecology and political economy literature on this subject. Activities in many climate-smart villages/territories build on previous interventions by programs or projects and use existing approaches and methodologies, perhaps with some adaptation. For example, CCAFS is using the farmer field school approach in Guatemala promoted by a regional

center dedicated to agriculture, agroecology, and sustainable use of natural resources (Tropical Agricultural Research and Higher Education, CATIE). Originally, the farmer field school approach focused on integrated pest management, but later evolved to other natural resource management challenges, such as maintaining/improving soil fertility and the conservation of agrobiodiversity. The module also includes a critical review of the climate-smart village approach, which has been criticized by some authors for being too technology centered and not concerned enough with social equity [8]. In module 4 (see below), course participants are asked to think critically about this issue and address it in the development of their action plans.

2. Climate information management for decision-making on agriculture and food security and its application in a regional context.

    - Climate information and products to design appropriate adaptation actions with a participatory/user-centered approach: monitoring, forecasting, and early warning systems.
    - Status of climate information products in Guatemala and the region.
    - Co-production of climate products to generate relevant recommendations: the experience of the Agroclimatic Technical Roundtables.
    - The participatory integrated climate services for agriculture (PICSA) methodology and its application in the Trifinio Region.
    - Use of agro-climatic information for a seasonal hunger early warning system using the example of the Food and Nutrition Security Secretariat (SESAN for its Spanish acronym) 'Situational Room' and its application in the Dry Corridor.

This module focuses on how best to provide tailored agro-climatic services and food security information for better decision making at various levels ranging from national to municipal [4,20]. The Municipal Food and Nutrition Security Council (COMUSAN for its Spanish acronym) is part of the municipal government structure and includes government and non-government actors working on food security. Together with a community-based food security early warning system at municipality level, the council is supposed to improve climate resilient planning and implementation. The councils will be set up in all municipalities of the country, based on a political decision made by the Food and Nutrition Security Secretariat . This assures political support but does not guarantee sustainability. The module highlights that what looks promising on paper does not always work out in practice, certainly not if there are institutional challenges (e.g. high turnover of staff, new policy guidelines, corruption), and implementation is obstructed by perverse mechanisms, such as handouts, to gain political support.

3. Collaboration and financing opportunities for adaptation to climate change in the Trifinio Region.

    - Public policies related to climate change.
    - Contributions of the international cooperation agenda for adaptation to climate change.
    - Organizations of local actors.
    - A critical review of scaling strategies: concepts, practices, and challenges.
    - Resources available for adaptation to climate change and policy advocacy spaces (scaling up).

In module 3 of the course, the concept of scaling is critically examined. In the work of CCAFS globally, scaling has been an important and recurring topic. Over the years, CCAFS scaling mechanisms tested across the regions included:

- Horizontal scaling (scaling out) of climate-smart options: climate-smart villages provide demonstration sites for farmer-to-farmer learning and/or to enable local promotion of options through local government plans, programs, and policies or through private-sector business models.
- Vertical scaling (scaling up): climate-smart village research and lessons learned provide evidence for the efficacy of practices, technologies, services, processes and institutional

options and are thus able to influence large-scale climate-smart agriculture investment plans, promote mainstreaming of institutional changes, and/or inform policy instruments.

Scaling mechanisms expected to be useful, according to CCAFS, include agricultural and climate (change) related policies, government (investment) programs, improved supply chains, information and communication technologies (e.g. agro-advisories), impact investment by the private sector, financial services, and social networks (e.g. farmer-to-farmer exchanges). Westermann et al. [21,22] underline that CCAFS scaling is required to achieve impact beyond plot or site level and reach more people over wider areas (scaling out or horizontal scaling), impact institutions and policies that drive interest in scaling up (vertical scaling), and have a substantive impact on poverty. They argue that inherent in the notion of climate-smart agriculture is the need for hundreds of millions of smallholder farmers to adopt climate-smart practices and technologies, which will inevitably involve new and innovative ways of moving to scale.

In the module, it is argued that the CCAFS notion of scaling needs refinement as it appears overly simplistic and too linear and instrumentalist, ignoring the fact that technology development, adoption, and adaptation are part of a social process imbedded in larger societal configurations and processes [23]. These configurations and processes are usually the result of a long history characterized by resource competition, conflicts and struggles, but also by forms of collective action, coordination and cooperation. For climate-smart technologies to work in a given region, such as the Dry Corridor of Guatemala, they need to add value to existing natural resource management knowledge and the practices of farmers. Building on the work of Wigboldus and his colleagues [24–26], the course introduces a more nuanced, dynamic, and non-linear understanding of scaling drawing on insights from the social sciences. It also introduces two other scaling pathways to complement scaling out and up: scaling down and scaling to the future [23]. Scaling down implies reaching out to farmers not directly involved in climate-smart village or TeSAC activities. Scaling to the future means training the upcoming generations of professionals who will work on climate-smart agriculture and adaptation to climate change (such as the participants in the course described here).

4. Design and planning of initiatives to adapt to climate change.

- Strategic and project planning concepts.
- The project cycle and logical framework.
- The framework of community capital and its application in the preparation of situational analyses.
- Identification of impact pathways and strategies with key actors.
- Design of objectives, indicators, and activities; identification of assumptions.
- Elements for monitoring and evaluation.

In this final module, course participants from different organizations interacted in working groups to share their experiences and practical knowledge, incorporate new learning acquired through previous modules, and develop a project profile for adaptation to climate change following the results-based approach, considering aspects of scaling, as well as financial and institutional sustainability. Each group presented its plan in plenary and received feedback from the other participants.

3. Course Results

3.1. Diverse Group of Participants.

32 people (19 men and 13 women) enrolled in the first run of the diploma, of whom 30 obtained graduation and participation diplomas (18 men and 12 women, respectively) by completing different levels of attendance and delivery of individual work. Only two people withdrew from the diploma course during the development of the modules, which constitutes a normal percentage compared to other diploma courses inside and outside CUNORI. The different trajectories and experiences of the professionals favored lively exchange of knowledge. Technicians and professionals with a Bachelor's

or Engineering degree with different backgrounds and careers participated; all of them actively work in organizations in the Dry Corridor of Guatemala as extension agents, technicians, rural development promoters and project managers across 14 organizations in nine municipalities of the Dry Corridor of Guatemala and one organization based in Honduras.

3.2. Integration of What Has Been Learned in Institutional Work

Participants identified concrete opportunities to apply what they learned in the course to their own organization in the short term. An example of this is provided in the exercise carried out by personnel from the Ministry of Agriculture, Livestock and Food (MAGA) in the region:

Exercise: What opportunities exist for the application of what was learned in the university course, to be implemented in 2020, in activities already planned or to be planned?

- We can apply them in each Municipal Rural Extension Agency (AMER), training and strengthening the knowledge of each technician for implementation or strengthening in the Learning Centers for Rural Development (CADER) of each municipality.
- Strengthening the application of the farmer-to-farmer extension methodology.
- Integrating it into the Family Farming Program for the Strengthening of the Rural Economy (PAFFEC).

3.3. Integration of What Has Been Learned in the Formulation of Adaptation Proposals

What was learned in the first three modules was applied by the participants in an adaptation project design exercise, which was the subject of module 4. Participants self-organized in groups according to their interest in particular adaptation issues. They carried out a situational analysis and designed theories of change aimed at positively influencing the adoption of adaptation measures appropriate to the context of farmers in the region. Some examples of the main objectives of the different projects are:

- To encourage farmer families use appropriate bean varieties for each season in the community.
- To encourage farmer families to decide about appropriate agricultural practices on their plots with the support of the recommendations of the Agroclimatic Technical Roundtable.
- To help families install and maintain water collection infrastructure.

In each project's theories of change, participants also identified desired changes in community groups, municipalities, organization consortia, and other actors working with farmer families. Some examples of these changes that show the use of agroclimatic information, territorial focus, and scaling strategies are:

- The Agroclimatic Technical Roundtable validates agroclimatic bulletins according to the needs of farmer families.
- Learning Centers for Rural Development disseminate seed options for different climatic conditions among farmer producers.
- Organized groups of coffee producers, supported by the Micro-Watershed Committee, manage financing to establish forest systems.

4. Conclusions

Based on the course evaluations by participants and teachers, the first edition of the course at CUNORI was successful. The subject matter of the course was considered to be highly relevant to the professional activities of the course participants, most of whom are in the domain of natural resource management and rural development. The sustainable territory approach brings together insights from agroecology, the conservation and sustainable use of agrobiodiversity, climate science, political science, and rural development as inputs for the design of sustainable livelihood development interventions. Participants remarked that there are not that many courses that offer such an integrated

perspective on current development challenges. They also mentioned that valuable new concepts and skills about climate-smart agriculture and climate change adaptation were acquired. The interactive, participatory course approach and methodology were especially appreciated.

From the reflections of the participants and organizers of the course, aspects that should remain in future editions of the diploma course and others that must be modified and improved were identified. The major ones are:

- Selection of participants. Groups of 25 to 30 participants will be kept because this group size favors discussions of a high theoretical and practical level. For this, the criteria used to promote diversity in the group must also be maintained, promoting the participation of women and people with field experience from local organizations.
- Institutional commitment and user-based design. In future editions, agreements will be established with the organizations represented by the selected participants. These agreements will have two objectives. The first will be to define specific training needs for adaptation to climate change in the framework of the TeSAC approach in order to adjust the content and teaching material of the diploma course. The second will be the definition of operational plans for the execution of post-course actions. This seeks to make the investment in the course more strategic for scaling up the TeSAC approach.
- Course structure. The course design has been validated in this first edition, and the perception of instructors and participants is positive regarding the relevance of selected topics and the logic and consistency of the sequence. However, the design will have a degree of flexibility to meet the needs of new users (see previous point).
- Didactic strategies. This aspect contains several opportunities for improvement, such as introductory activities by instructors for participants to make better use of the virtual platform, analysis of didactic material to avoid gaps and redundancies, and ongoing evaluation to encourage participants to stay up-to-date and in tune. Module 4 will also be modified to formulate or review real projects in each organization.
- Follow-up. Monitoring and evaluating the impact of the course in the participating organizations is key, so a protocol for follow-up interviews will be designed and applied to find out if and how the concepts and practices disseminated are being applied.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Detailed course content.

Module	Content
1. Practices and technologies for adaptation to climate change in the Trifinio Region: systematization of	• Welcome and introduction to the diploma course • The course learning e-platform: use and rules

experiences and selection criteria for their implementation	• Introduction of Module 1 • Climate change: key concepts • Climate change and its main impacts on rural livelihoods in Central America and the Trifinio Region (current situation and scenarios) • Climate-smart agriculture and a territorial approach for adaptation to climate change: introduction • Gender and climate change adaptation • Adaptation practices and technologies based on agrobiodiversity and sustainable management of crops, livestock, water, and soil: theory and results • Lessons learned from the CCAFS program around the world • Territorial approaches in Latin America: country examples • Decision-making methodology for the selection of viable practices and technologies and their adaptation to local conditions • Guest speakers (5): adaptation experiences from Guatemala (governmental and non-governmental case studies) • Evaluation of Module 1
2. Climate information management for decision-making on agriculture and food security	• Examination of Module 1 • Introduction of Module 2 • Climate information and products to design appropriate adaptation actions with a participatory/user-centered approach: monitoring, forecasting, and early warning systems • Climate information products in Guatemala and the region: an overview • Climate risk management • Co-production of climate products to generate relevant recommendations: the experience of the Agroclimatic Technical Roundtables • The NextGen program (webinar) • The Participatory Integrated Climate Services for Agriculture (PICSA) methodology and its application in the Trifinio Region: 4 presentations • Use of agro-climatic information for a seasonal hunger early warning system: the example of the Food and Nutrition Security Secretariat (SESAN) Situation Room and its application in the Dry Corridor • Plenary discussion • Evaluation of Module 2
3. Collaboration and financing opportunities for adaptation to climate change in the Trifinio Region	• Examination of Module 2 • Introduction of Module 3 • Public policies related to climate change relevant to the Trifinio Region: presentation

	• Contributions of the international cooperation agenda for adaptation to climate change in the Trifinio Region • Organizations of local actors in the Trifinio Region: poster session and show and tell • Scaling strategies of concepts, practices, and technologies (scaling up, down, horizontal and future): introduction • Presentation of mini-essays about scaling • Scaling down: lessons learned from the Farmer Field School experience in Central America • Scaling up: resources available for adaptation to climate change and policy advocacy spaces • Policy debate • Future scaling: the experience of CUNORI • A critical review of the concept and practice of scaling of CCAFS • Evaluation of Module 3
4. Design of initiatives to adapt to climate change	• Examination of Module 3 • Introduction of Module 4 • Strategic and project planning concepts • The project cycle and the logical framework • The framework of community capital and its application for the preparation of diagnoses • Identification of impact routes and work strategies with key actors • Design of objectives, indicators, and activities, identification of assumptions • Presentation of action plans; questions and answers • Evaluation of Module 4 • Diploma ceremony • Diploma course closure

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