

Carbon inseting in the dairy value chain

6. Project Partners

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7. State of Project Implementation and Assessment

The project had three primary lines of activity:

1. Exploring, analyzing and applying existing data on greenhouse gas emissions, climate change impacts, adaptation needs and carbon stocks and sequestration potential with a focus on livestock (dairy) and forages.
2. Conducting a case study to validate conclusions from existing data and to determine best practices for training and implementation of activities at the farm level.
3. Determining the optimal partnership structure for scale-up of carbon inseting-initiatives, including incentive mechanisms and engagement of the private sector, as well as establishing the appropriate reporting, monitoring and training procedures.

The outputs were as follows:

1. Prediction of climate impacts and adaptation needs of participating livestock producers, by
 - a. Quantifying exposure of livestock systems to progressive climate change (*partially achieved*)
 - b. Analyzing sensitivity and capacity of dairy smallholders to cope with climate changes (*partially achieved*)
2. Assessment of greenhouse gas emissions, carbon stocks and carbon sequestration potential from livestock related practices (*achieved*)
3. Assessment of the socio-economic implications of carbon efficient livestock practices (*achieved*).
4. Empirical evaluation via case study at community and household level at a specific research (pilot) site in collaboration with the private sector and development institutions (*partially achieved*).
5. Development of a Project Design Document (PDD) to implement a carbon inseting initiative (*not achieved*).
6. Dissemination of carbon inseting potential in smallholder dairy value chains at policy level. This will be achieved by summarizing conclusions in a policy brief and sharing this brief at a workshop in the North (Germany) (*partially achieved*).

The field work was conducted in three municipalities in central Nicaragua, Matiguás, Muy Muy and Camoapa, the most important dairy producing region.

1.a. Quantifying exposure of livestock systems to progressive climate change

The main conclusion of a study by Phelan (2015) is that during the last 10 years almost all smallholder farmers have noticed differences in the climate and weather patterns impacting on their farm, especially regarding ambient temperature (increase), rainfall (decrease), drought occurrence (increase). Table 1 provides more details.

Table 1: Perception of climate change impact on Muy Muy and Matiguás

	Perception of change
Temperature	Higher = 95%; Lower = 5%;
Precipitation	Higher = 37.5%; Lower = 57.5%; Constant = 5%
Wind	Higher = 20%; Lower = 45%; Constant = 35% *
Heat	97.5% higher; Constant = 2.5%
Drought frequency	Higher = 60%; Lower = 22.5%; Constant = 17.5%
Length of dry season	Shorter = 42.5%; Longer = 52.5%; Constant = 5%
Length of rainy season	Shorter = 57.5%; Longer = 32.5%; Constant = 10%

1b. Analyzing sensitivity and capacity of dairy smallholders to cope with climate changes

The production risks which smallholder farmers perceived as associated with climate change are indicated in Table 2 below. Farmers notably perceived a decline in milk yield.

Table 2: Production risks induced by climate change

Milk yield	Decreased = 57.5%; Increased = 7.5%; Constant = 35%
Calving rate	Decreased = 17.5%; Increased = 20%; Constant = 62.5%
Calving age	Decreased = 30%; Increased = 20%; Constant = 50%
Calving interval	Decreased = 17.5%; Increased = 20%; Constant = 62.5%
Body weight	Decreased = 22.5%; Increased = 15%; Constant = 62.5%

This output was mainly addressed through a survey among 45 small, medium and large farmers in Muy Muy and Matiguás municipalities in Central Nicaragua (Köngeter, 2015).

Short- and long-term coping strategies differ between farmer categories. For the first, small farmers use their human capital (e.g., as labourers at other farmers or seasonal migration to Costa Rica), whereas larger farmers are more likely to sell animals or implement technical solutions. Long-term strategies for all farmers include changes in cropping cycles, and as a last resort especially smaller farmers tend to migrate to the more humid Caribbean region.

Coping strategies included using savings by almost all farmers (92.5%) to improve production systems and looking for options to diversify production (82.5% of the farmers), for instance by adopting improved forages, or planting crops in dispersed areas to spread risks. As can be seen in Table 3, especially small farmers took loans, mainly informal from intermediaries.

Table 3: Coping strategies used by smallholder farmers in the last two seasons

	Smallholders	Medium producers	Large producers
S H O R T T E R M	<ul style="list-style-type: none"> • Sell animals • Borrow cash (eg. Intermediaries) • Off-farm employment & remittance 	<ul style="list-style-type: none"> • Switch to semi-formal market • Sell animals 	<ul style="list-style-type: none"> • Rotation systems and land adquisition • Sell in november or „a medias“ • Technical solutions: irrigation & improved grasses avoid exposition • Switch to semi-formal market
L O N G T E R M	<p>Long-term changes in production systems</p> <ul style="list-style-type: none"> • „La gente no está acostumbrada“ • Rely on external help (NGO) <p>• Farm diversification</p> <p>• Adapt calender</p> <p>• Migration to cheaper humid areas</p>	<ul style="list-style-type: none"> • Technical solutions to improve access to water (within financial/knowledge limits) • Improved grasses • Political pressure and collective action for public improvements (forestation, better access) • Migration as risk, as social network is crucial 	<ul style="list-style-type: none"> • Embedded in national and international networks • Improve cattle breed • Forestation

The potential to integrate smallholder farmers in formal value chains is limited. Households with little access to livelihood assets have few opportunities to meet (international) quality and quantity requirements, and many are poorly connected to farmers' organizations like cooperatives and "external" actors like public sector institutions and NGOs.

The dependence of small farmers on informal markets and seasonal effects (feed availability, fluctuating prices) reduce also the possibilities to be part of formal value chains and this exacerbated by the impact of climate change. Due to sociocultural factors that induce gender inequalities related to access to resources like land women are affected even more.

New developments in certification schemes for commodity value chains in this case study on form a potential of carbon insetting in the dairy and meat value chain in Nicaragua, being a potential effective tool to tackle deforestation and accelerated greenhouse gas emissions. Participation in carbon insetting initiatives can be an incentive for small and medium farmers to meet international (certification) standards and have access to global value chains. However, those having access to good infrastructure (roads) will benefit disproportionately, most of them being larger farmers.

The impact of certification schemes on food and nutritional security has been low, products generally being luxury commodities in line with the preferences of global consumers like cocoa and coffee. In the case of dairy and beef there might be a positive effect, if such schemes like carbon insetting incentivise farmers to increase productivity, product quality and natural resource integrity also having positive local impact and increasing high quality food availability for poorer groups.

Concluding, carbon insetting:

- Will only have impact if access of small and medium farmers to institutions, markets and infrastructure will be increased

- Can be a powerful instrument to prevent deforestation, recuperate degraded lands and decrease greenhouse gas emissions per unit of product

2. Assessment of greenhouse gas emissions, carbon stocks and carbon sequestration potential from livestock related practices.

An extensive literature review was conducted to collect information on previous work done on the study area. Based on this research, a simple and accessible methodology was selected, able to achieve the objective and to meet the livelihood needs of the producers.

The baseline data collected by Heifer International as part of the project “Competitive beef and dairy through sustainable intensification and specialized market access”, allowed us to visualize and characterize the study area regarding aspects that influence greatly GHG emissions and carbon sequestration, such as land use, farm infrastructure, herd, animal composition among others. From this data, 30 farms of small and medium holders, where livestock is their main activity and income, were selected for a detailed study by Gaitán et al. (2016) (completed).

Five systems were identified and selected to measure the data which allowed us to calculate the carbon stocks on livestock related practices:

- improved pasture with trees (IPT)
- improved pasture without trees (IP)
- traditional pasture with trees (NPT)
- traditional pasture without trees (NP)
- secondary forest (SF)

Selection criteria included relevance and presence on the farms, as well as potential on carbon sequestration.

To calculate the carbon stocks, a tree inventory was conducted. The availability of forage biomass (improved grasses *Brachiaria brizantha* (Toledo and Marandu) and traditional grass *Paspalum spp.*) was calculated based on the frequency and botanical composition. Below ground soil carbon stocks were assessed through secondary data.

The SF land use has a significantly higher carbon stock than other land uses, due to more woody and herbaceous biomass, including litter. IP has a significantly higher herbaceous biomass than NP. Land uses with improved grasses show higher carbon stocks than their equivalents with natural grasses, whereas carbon stocks in SF were higher than all other land uses. Soil carbon stocks did not differ significantly between the different land uses.

To calculate GHG emissions an indirect methodology was applied using a modified questionnaire structured by CATIE (Tropical Agricultural Research and Higher Education Center, based in Costa Rica and one of CIAT's partners in the region). Estimates of total GHG emissions included animal digestion processes, farm operations and production of external inputs. Methane emissions from enteric fermentation account for 53-67%, making it the major source, followed by nitrous oxide from manure (13-17%) and from fertilizer (8-15%). Emissions from digestion processes differ between the category of animals, with lactating cows emitting most and varying least. Herd structure and production per cow therefore account for the different levels of emissions from livestock.

Strongly related to this work, we assessed the environmental sustainability of the dual-purpose cattle value chain in Nicaragua in terms of soil and GHG impacts of three best-bet intervention

scenarios for adaptation to climate change and increased livestock production: (i) improved silvopastoral systems, (ii) improved pastures and (iii) fodder banks (cut and carry grasses and legumes). All scenarios show increased productivity, resource-use efficiency and carbon accumulation, as well as decreased GHG emissions per unit of produce. To be able to increase environmental sustainability, the improved forage-based technologies in the different scenarios also need to be accompanied by better management practices and a favourable policy environment. The generation of rapid results highlighting the main environmental issues helps the program and its partners to tweak technology-based interventions and encourages the various value chain actors to apply alternative development pathways.

3. Assessment of the socio-economic implications of carbon efficient livestock practices, including cost-benefit analyses to determine the most profitable and sustainable activities.

The feasibility of carbon insetting as an innovative climate change mitigation and adaptation strategy enabling actors along the dual-purpose cattle value chain in Nicaragua to realize 'quadruple-win' outcomes (social, economic, environmental and productivity benefits) was assessed by Phelan (2015). The results of the study indicate that it would be feasible to implement a PES mechanism explicitly designed to generate 'quadruple-win' benefits for the buyers and providers in Nicaragua. The extensive nature of dual-purpose cattle production ensures that actors in the milk value chain have a comparative advantage in terms of production costs (due to use of natural forages in combination with improved grasses as feed, as opposed to concentrate feeds), and are highly competitive in export markets for both beef and dairy products. Successful carbon insetting scheme outcome is contingent on the ecosystem service buyers' willingness to pay, as well as underpinning motives to realize social, economic, and environmental and productivity gains through investment in ecosystem service provision.

Carbon insetting provides a platform for value chain actors, with divergent and perhaps conflicting interests, to collaborate in adapting to and mitigating climate change. It enables them to add value to the value chain, improve commercial relationships, access to new markets, and paves the way for products to be certified as low-carbon or carbon neutral. Enhancing the traceability and quality of products, carbon insetting can generate profits which can be shared and reinvested to improve the livelihood security and sustainability of smallholder farmers engaged in dual-purpose cattle production (Phelan, 2015).

The certification potential of 20 model farms was evaluated using a semi-formal survey based on criteria and components being part of the Sustainable Agriculture Network (SAN) norms. Farms complied mostly on integrated livestock management, sustainable pasture management and measures to reduce the carbon footprint. In general they showed a positive carbon balance, due to good tree cover offsetting livestock generated greenhouse gas emissions. Workshops were held with farmers about the benefits of farm certification and best management practices.

4. Empirical evaluation via case study at community and household level at a specific research (pilot) site in collaboration with the private sector and development institutions.

Based on GHG emissions and milk production, from the 30 original farms we selected 16 small- and medium-sized and allocated them to one of three categories: subsistence system, conventional market system, and climate-smart system. Five farmers used milk for home consumption only; five were commercial producers while the remaining six used climate-smart management. The latter seek high milk yield while managing their farms to adapt to and to mitigate climate change. They combine grazing, pasture and herd management, with feed supplements,

trees and judicious application of inputs to create climate smart management. Although the exact combination is constrained by farm size it provides resilience in the face of climate change. The main emphasis is milk production, which provides 74% of farm income, the remaining 26% coming from meat.

Emissions of subsistence-oriented and market-oriented systems were highest with resp. 3.1 and 2.4 kg of CO₂ equivalent per kg of milk, with climate smart farms showing only 1.7 kg of CO₂ equivalent per kg of milk. Climate-smart systems are being implemented, albeit still at a small scale. Improved forage-based systems are hardly adopted by subsistence- and market-oriented farmers because there are no incentives and often policies provide inadequate support. The private sector however is starting to reduce their carbon footprint by investing in carbon credits. Livestock production systems in Central America can reduce their carbon footprint by improving productivity and realizing social, economic and environmental benefits. Well-managed, mixed crop-livestock systems based on forages increase the quality of animal feed and reduce methane and N₂O emissions, particularly from enteric fermentation and adequate manure management. Growing trees in pastures increases the capacity of the system to accumulate carbon; high densities of sizable trees increase the carbon stocks. Secondary forest accounts for the highest carbon stocks, and should be considered as a vital farm component to provide different ecosystem services. Although promotions have increased the number of climate-smart farms, large-scale implementation will depend on adequate policies with effective incentives.

5. Development of a Project Design Document (PDD) to implement a carbon insetting initiative.

This output was not achieved, although a policy brief on carbon-insetting was produced at the onset of the project.

The concept of carbon insetting has not yet been adopted by smallholder farmers and private sector in the milk value chain in Nicaragua. However, there is growing interest at a national and international level at value chain and sectoral levels in identifying pathways towards more sustainable production of agricultural commodities such as meat, milk, coffee and cocoa.

The experience which CIAT gained in implementing the project in Nicaragua is currently being used to develop and implement a project with and for the cocoa sector in Indonesia. Together with the Sustainable Cocoa Production Program (SCPP) - lead by SwissContact integrates the public and private sector, including BT Cocoa, Barry Callebaut, Cargill, Ecom, JB Cocoa, Mars, Mondelez International and Nestlé – CIAT is working to enhance the economic, social and environmental aspects of sustainable cocoa production for the benefit of actors across the supply chain. SCPP aims to increase productivity while enhancing the environmental performance through mechanisms such as farmers training on good agricultural and environmental practices, traceability and certification. By being able to quantify the carbon footprint on cocoa farms, the program will be able to measure its impact thus contribute to reduction of 30% GHG emissions in cocoa sector.

CIAT is currently also in the process of joining the International Platform for Insetting (IPI), a non-profit organization which was set up in 2013, pre-launched by Plan Vivo at the inaugural conference on carbon insetting in London, 2014, and officially launched at the Paris Climate conference (COP21) in 2015. Managed by Pur Projet, IPI provides a platform for member organizations (academic, industry, project developers) to share knowledge and lessons learnt. It aims to give visibility to practices, thereby, promoting the development and implementation of carbon insetting projects worldwide. IPI will provide a unique space for CIAT to further share its experience of assessing the feasibility of carbon insetting in the milk value chain in Nicaragua.

6. Dissemination of carbon insetting potential in smallholder dairy value chains at policy level. This will be achieved by summarizing conclusions in a policy brief and sharing this brief at a workshop in the North (Germany).

The work has been presented at various occasions:

1. Two MSc. Thesis:

- Köngeter, C.A. (2015) Klimagerechte Wertschöpfungsketten über Carbon Insetting. Eine akteurszentrierte Analyse potentieller Auswirkungen auf der Produzentenebene am Beispiel der Fleisch- und Milchwertschöpfungskette in Nicaragua. MSc. Thesis. Geographisches Institut Rheinische Friedrich-Wilhelms-Universität Bonn.
- Phelan, L.T. (2015). Adding Value to Smallholder Forage-Based Dual-Purpose Cattle Value Chains in Nicaragua, in the context of Carbon Insetting. MSc. thesis. Institute of Animal Production in the Tropics and Subtropics, University of Hohenheim, Stuttgart

2. Presentation at inaugural conference on carbon insetting organized by Plan Vivo and hosted by the International Institute for Environment and Development (IIED), London in October 2014.
3. ICAE conference Milan (10-14 August 2015)
4. Presentation at “Steps to Sustainable Livestock” conference, Bristol, UK.
5. EAAP conference Belfast

However, a policy brief based on the projects results has not yet been produced.

8. Major Research Findings

Research activities are related to sustainable livestock development, value chain enhancement and climate change adaptation and mitigation (e.g., carbon accumulation, greenhouse gas emissions as a function of different farm types). The connection between sustainable livestock practices and a strong market/private sector focus, linking biophysical and socio-economic aspects of carbon accumulation-related incentive mechanisms and paying attention to genetic improvement of livestock in a wider farm-household context deals now with most value chain components, leading to an integrated approach that strengthen the entire value chain.

The work on the identification, development and implementation of “best practices” aimed at sustainable intensification of livestock production has continued as part of some bilateral projects, and is strongly connected to research on incentive mechanisms for sustainable livestock production, like generating carbon credits and integrating their purchases into supply chains (“carbon insetting”). Furthermore, we have looked into the socio-economic aspects at farm level such as the trade-offs between use of biomass as animal feed versus for carbon accumulation, market perspectives and willingness to pay by the private sector.

part of the BMZ-funded Carbon Insetting project, best-bet livestock-related practices suitable for carbon credit certification at the smallholder farm level are being identified, including assessments of carbon stocks and GHGs. Thirty farms were characterized in respect of land use, farm infrastructure, geography, and herd composition. Carbon stocks of grasses and trees were estimated in the four most representative grazing systems (natural pastures with or without trees, improved pastures with trees, improved pastures without trees), and secondary forest. Greenhouse gas emissions were estimated indirectly through a methodology based on an

inventory of human, social, natural, physical and financial capital. These activities fit with the LivestockPlus concept that will be developed further as part of Livestock and Fish work.

The certification potential of 20 model farms has been evaluated using a semi-formal survey based on criteria and components being part of the Sustainable Agriculture Network (SAN) norms. Farms complied mostly on integrated livestock management, sustainable pasture management and measures to reduce the carbon footprint. In general they showed a positive carbon balance, due to good tree cover offsetting livestock generated greenhouse gas emissions. Workshops were held with farmers about the benefits of farm certification and best management practices.

9. Assessment of Research Findings

Carbon insetting is expected to improve food security by sustainable practices, increase drought resilience, improve natural resources conservation and open new markets. Poor smallholders benefit as they are more vulnerable towards the effects of deforestation and climate change, facing more difficulties to access water resources and forages. Nevertheless, it might be difficult to include small producers in a carbon insetting market as they lack of organization and product quality according to international standards. There may be problems regarding the project's contribution to gender equality as livestock activities and decisions are carried out by male producers.

We have been able to create synergies with two closely related projects (FSP-Solidaridad, USAID Linkage project on sustainable grassland intensification). Making use of the farmers network of the FSP-Solidaridad project (mainly through the Cooperative Nicacentro in Matiguás) we have selected the representative farmers for measurements and the socio-economic survey, and in the final stage of this projects we will be able to disseminate results more easily. The US-Linkage project provides important biophysical data of grasses, legumes and trees, especially related to carbon content and nutritional value.

The feed and forages work will continue according to the same lines, with emphasis on improving management of feed resources with a focus on sustainable intensification as part of the LivestockPlus concept, improving the productivity of forage-based systems and at the same time reducing the ecological footprint of livestock production. Improving forage seed availability continues to be another important theme.

We will continue putting a strong focus on involving partners in the value chain work, especially related to sustainable livestock development and seeking markets for products with added value. We expect to continue developing novel approaches and involving several stakeholders in establishing a sustainable livestock platform at national level and territorial learning alliances in our intervention sites, while increasing focus on improving the availability of animal source food for the poor.

10. Know-How Transfer

Research findings have been shared with various partners and other institutions:

- The research and education centre CATIE, mainly on exchange of methodologies
- The findings on carbon accumulation potential and practices/technologies to reduce greenhouse gas emissions at farm level have contributed to other projects (e.g., FSP-

Solidaridad) and the CRP Livestock and Fish, and have resulted in a scientific article (currently under review).

- Cooperative Nicacentro, Heifer International: party based on project findings, over 1000 farmers have been trained on establishing best practices to meet international standards for sustainable livestock production.
- With Solidaridad Network: findings have been used as input to develop a proposal on the development and implementation of sustainable silvopastoral systems to address land use pressures through an integrated spatial planning approach in the Southern Autonomous Caribbean Region (RACS) of Nicaragua
- With Mississippi State University (MSState) and the University of Wisconsin – River Falls (UWRF): research findings are used to develop spatial forage availability and carbon accumulation potential models, to be able to quickly establish carbon accumulation potential at farm level
- During various presentations at national institutions like INTA (the Nicaraguan Agricultural Research Institute) and CONICYT (the Nicaraguan Council for Science and Technology), and sector organizations (like CANISLAC, the Nicaraguan chamber of dairy) the carbon insetting was presented as well as research findings.
- With the Norwegian University of Life Sciences (NMBU) we have been doing work on systems dynamics modelling of the dual purpose cattle value chain, using research findings as model input.

11. Training

An important part of this work was implemented as part of two Master thesis “Climate-smart value chains by carbon insetting: An actor-oriented analysis of potential consequences on producer level, by the example of the dual-purpose livestock value chain in Nicaragua”, conducted by Alexandra Köngeter at the university of Bonn and “Adding Value to Smallholder Forage-Based Dual-Purpose Cattle Value Chains in Nicaragua, in the context of Carbon Insetting” by Lisette Phelan of the University of Hohenheim.

Besides this, a PhD student from the Norwegian University of Live Sciences (NMBU) developed a systems dynamics model on the dual purpose cattle chain, with focus on dry season feeding and milk quality, with many inputs the project and strong involvement of value chain stakeholders (farmers, technicians, private sector, cooperatives, public sector) from the Matiguás area. The results are still being analysed.

As part of 20 Farmer Field Schools almost 500 farmers in the region benefitted indirectly from the project’s research results, receiving trainings on improved (mainly drought adapted) forages, pasture management, greenhouse gas emissions, carbon accumulation potential and certification requirements. They have applied various sustainable livestock practices on their farms, establishing 4,000 ha of silvopastoral areas, and bringing 25,000 heads of cattle brought under sustainable management, increasing milk production of over 300 farmers.

The Farmer Field Schools (FFS) continued this year, allowing farmers to implement silvopastoral systems, better cattle management practices, and the application of new techniques for farm management as well as the cultivation of new forage species allowing farmers to improve the diets of cattle and thus milk productivity. L&F outputs contributing to the capacity building include research results on improved (mainly drought adapted) forages, pasture management, greenhouse gas emissions and carbon accumulation potential, and certification requirements.

12. Lessons Learned

Carbon insetting is expected to improve food security by sustainable practices, increase drought resilience, improve natural resources conservation and open new markets. Poor smallholders benefit as they are more vulnerable towards the effects of deforestation and climate change, facing more difficulties to access water resources and forages. Nevertheless, it might be difficult to include small producers in a carbon insetting market as they lack of organization and product quality according to international standards. There may be problems regarding the project's contribution to gender equality as livestock activities and decisions are carried out by male producers.

Although some work has been done on market research and business models, this component needs much more attention because uncertain and volatile markets and lack of transparency on payment for quality are major hindrances for smallholder milk and beef production.

Another key need is access to financial resources for investments in sustainable intensification, increasing added value of livestock products and institutional reinforcement.

Other issues to be addressed include a national quality based milk payment system, how to increase public and private policy incidence on sustainable livestock development (farmer incentive mechanisms, sustainable supply chain, certification of sustainable livestock products). Main barriers for smallholders to implement climate-smart practices are the lack of long-term training and information and financial limitations to do the required initial investments.

We have been able to create synergies with two closely related projects (FSP-Solidaridad, USAID Linkage project on sustainable grassland intensification). Making use of the farmers network of the FSP-Solidaridad project (mainly through the Cooperative Nicacentro in Matiguás) we have selected the representative farmers for measurements and the socio-economic survey, and in the final stage of this project we will be able to disseminate results more easily. The US-Linkage project provides important biophysical data of grasses, legumes and trees, especially related to carbon content and nutritional value.

Although gender was not among the project's most important components, the inclusion of women farmers is essential for a greater impact. While some women were involved in the project, it is important to note that beyond quantifying their participation, for their effective inclusion, it is important to go further.

To transform the livestock sector, knowledge gaps must be addressed around livestock product markets, and also including the beef sector.

13. Future Research Needs

- We have not yet been sufficiently able to involve the private sector in the development and implementation of the carbon insetting concept in the livestock sector. More research (and expertise) is needed on the business development part.
- Another (related) theme is the development of incentive mechanisms leading to the adoption of sustainable practices along the dairy/dual purpose cattle value chain, by both farmers and processors. Currently a PhD student from Wageningen UR is doing research on adoption of agro-ecological farming and we believe that her findings will contribute importantly to further developing the carbon insetting concept.

14. Summary

The project had three primary lines of activity:

1. Exploring, analyzing and applying existing data on greenhouse gas emissions, climate change impacts, adaptation needs and carbon stocks and sequestration potential with a focus on livestock (dairy) and forages.

During the last decade almost all smallholder farmers have noticed differences in the climate and weather patterns impacting on their farm, especially regarding ambient temperature (increase), rainfall (decrease), drought occurrence (increase). Coping strategies differ strongly between farmer categories. Small farmers use their human capital as labourers, whereas larger farmers tend to sell animals or implement technical solutions requiring investment.

At the livestock farms in the Matiguás research area the major source of greenhouse gas (GHG) emissions is methane from enteric fermentation (accounting for 53-67%), followed by nitrous oxide from manure (13-17%) and from fertilizer (8-15%). Land uses with improved grasses show higher carbon stocks than their equivalents with traditional grasses, whereas carbon stocks in secondary forest were higher than all other land uses. Soil carbon stocks did not differ significantly between the different land uses. Main conclusion that presence of trees is the most important factor contributing to carbon accumulation.

2. Case study to validate conclusions from existing data and to determine best practices for training and implementation of activities at the farm level.

Of three farm categories (subsistence system, conventional market system, and climate-smart system), carbon stocks of grasses and trees were estimated in the four most representative grazing systems (natural pastures with or without trees, improved pastures with and without trees), and secondary forest. Greenhouse gas emissions were estimated by means of a life cycle analysis.

Emissions of subsistence-oriented and market-oriented systems were highest with resp. 3.1 and 2.4 kg of CO₂ equivalent per kg of milk, with climate smart farms showing only 1.7 kg of CO₂ equivalent per kg of milk. Although climate-smart systems are being implemented at a small scale, improved forage-based systems are hardly adopted by subsistence- and market-oriented farmers because there are no incentives and often policies provide inadequate support.

Growing trees in pastures increases the capacity of the system to accumulate carbon; high densities of sizable trees increase the carbon stocks. As secondary forest accounts for the highest carbon stocks, and should be considered as a vital farm component to provide different ecosystem services.

3. Determining the optimal partnership structure for scale-up of carbon insetting-initiatives, including incentive mechanisms and engagement of the private sector, as well as establishing the appropriate reporting, monitoring and training procedures.

It is feasible to implement a Payment for Ecosystem Services mechanism such as carbon insetting explicitly designed to generate 'quadruple-win' (social, economic, environmental and productivity) benefits for buyers and providers in Nicaragua. Actors in the milk value chain have a comparative advantage in terms of production costs and are competitive in export markets. A successful carbon insetting scheme outcome is contingent on the ecosystem service buyers'

willingness to pay, as well as underpinning motives to realize social, economic, and environmental and productivity gains through investment in ecosystem service provision.

Carbon insetting provides a platform for value chain actors, with divergent and perhaps conflicting interests, to collaborate in adapting to and mitigating climate change. It enables them to add value to the value chain, improve commercial relationships, access to new markets, and paves the way for products to be certified as low-carbon or carbon neutral.

However, the potential to integrate smallholder farmers in formal value chains is still limited. Many are poorly connected to farmers' organizations like cooperatives and "external" actors like public sector institutions and NGOs. New developments in certification schemes for commodity value chains form a potential for carbon insetting in the livestock value chains in Nicaragua, tackling deforestation and reducing GHG emissions. Participation in carbon insetting initiatives can be an incentive for small and medium farmers to meet international (certification) standards and have access to global value chains, but this will only have impact if their access to institutions, markets and infrastructure will be increased.

15. Publications, Papers and Reports

Gaitán L., Läderach P., Graefe S., Rao I., Van Der Hoek R. (2016). Climate-smart livestock systems: An assessment of carbon stocks and GHG emissions in Nicaragua. Submitted to PLOS ONE, currently under review.

Köngeter, C.A. (2015) Klimagerechte Wertschöpfungsketten über Carbon Insetting. Eine akteurszentrierte Analyse potentieller Auswirkungen auf der Produzentenebene am Beispiel der Fleisch- und Milchwertschöpfungskette in Nicaragua. MSc. Thesis. Geographisches Institut Rheinische Friedrich-Wilhelms-Universität Bonn.

Läderach P., Van der Hoek R., Gaitán C., Phelan L., Köngeter A., Mena M. (2015). Carbon insetting in the dual purpose cattle value chain in Nicaragua. Presentation at ICAE, Milan.

Notenbaert A., Van der Hoek R., Mena M., Paul B., Birnholz C., Mora A. (2016). Towards a sustainable dual-purpose cattle value chain in Nicaragua. Presentation at "Steps to Sustainable Livestock" conference, Bristol, UK.

Phelan, L.T. (2015). Adding Value to Smallholder Forage-Based Dual-Purpose Cattle Value Chains in Nicaragua, in the context of Carbon Insetting. MSc. thesis. Institute of Animal Production in the Tropics and Subtropics, University of Hohenheim, Stuttgart

Van der Hoek R., Paul B., Birnholz C., Mena M., Mora A., Notenbaert A. (2016). Towards the sustainable transformation of cattle value chains in Nicaragua. Abstract accepted for oral presentation at EAAP (European federation of Animal Science) Annual Meeting 2016, Belfast, UK.