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Socio-economic, political, and institutional sustainability of agroforestry in Alta Verapaz, Guatemala

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Abstract

Promoting sustainable agricultural practices such as agroforestry (AF) could improve long-term productivity, enhance a sustainable rural livelihood and reduce pressure on natural resources and ecosystems in the tropics. However, AF seems to have adoption problems due to external market forces, lack of skills, financial resources and know-how ending in low flexibility and discontinuity of farmers in practicing AF. The objective of this study is to identify social, institutional, and economic factors that influence the adoption of AF on the household and community level, taking the region Alta Verapaz in Guatemala as a case study. Alta Verapaz is amongst the poorest regions in the country but also a tropical biodiversity hotspot where current agricultural practices are threatening forest environments and social development objectives. Our study explores how capital accessibility and institutional incentives are related to farmer's livelihood sustainability and AF compositions. The methodology is composed by semi-structured interviews with nineteen farmers and field observations. The interviews have been analysed based on a qualitative content analysis by using the inductive category development. Based on these outcomes, the study found that human and economical capitals are favoured in communities were institutions are present especially through AF training offers, creation of farmers cooperatives and economic incentives. The role of institutions resulted to be crucial in the promotion of organic AF methods, forest protection and creation of long-term income. The combination of agricultural diversification with institutional incentives is one key livelihood strategy adopted by the farmers in order to achieve a socio-economic and ecological sustainability of their households. The further promotion of community forestry projects, expansion of networks and ongoing agricultural trainings as well as the diversification of agricultural systems could be beneficial for farmers in Alta Verapaz.

Keywords: cardamom, cocoa, infrastructure, smallholdings, sustainable rural livelihood, vanilla

Abbreviations:

AF:	agroforestry,
NGO:	Non-governmental organisation,
INAB:	Instituto Nacional de Bosques,
SD:	Standard deviation

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1 Introduction

Smallholder agriculture forms the basis of subsistence for 2.5 billion people worldwide that belong to poor rural households, live and depend on a small-scale agricultural land with limited external inputs and earn their incomes in multiple ways (IFAD, 2013). It includes farming, forestry, fishery and animal husbandry and produces about 80 % of the food consumed by rural households living in develop-

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ing regions (Dixon *et al*., 2004; FAO, 2012; IFAD, 2013; Lowder *et al*., 2016) and is thus a key sector for food security, as it acts as main source of income and nutrition for a vast number of people (FAO *et al*., 2015).

Sustainable agriculture is a key commitment of national policies, international treaties and decision-makers at all levels to promote agricultural and rural development by improving quality of life and economic well-being of farmers. Moreover, international organisations such as the Food and Agriculture Organisation of the United Nations (FAO), the United Nations Framework Convention on Climate Change (UNFCCC), and the International Centre for Agroforestry Research (ICRAF) agree that in order to achieve sustainable development in rural areas it is important to invest into agriculture as an effective strategy for reducing poverty, hunger, and land degradation (Lowder *et al*., 2016). These international organisations recognize the importance of promoting resilient and sustainable agricultural practices like agroforestry (AF). The most common definition by Lundgren & Raintree (1983) describes AF as any land-use system that integrates woody perennials e.g. trees, shrubs, or palms on the same land unit as agricultural crops and/or animals with varying temporal sequence or spatial arrangement. The Millennium Ecosystem Assessment (2005, p. 47) underlines that "agroforestry can meet human needs for food and fuel, restore soils, and contribute to biodiversity conservation". AF is known to create manifold benefits to farmers for example income diversification and sustainability of production and profits, mitigation and resistance to climate change, and the sustainable use of natural resources (Nair, 1993; Buck *et al*., 1998; FAO, 2013; Atangana *et al*., 2014). Moreover, it has been proofed in many studies in Africa, Asia, and Latin America that AF systems are supporting sustainable resource and water management and act against environmental degradation, deforestation, and soil erosion in tropical as well as in temperate realms as they support ecosystem restoration and maintenance of biomass and biodiversity (Nair, 1993; Garrity *et al*., 2006; FAO, 2013; Atangana *et al*., 2014; Mbow, 2015; Vaast *et al*., 2016).

Half of the Guatemalan population (51.5 %) lives in rural areas (INE, 2004) while more than two thirds of the population depend on agriculture and forestry as main food and income source (Imbach *et al*., 2017). In Guatemala, agriculture is threatened by widespread and unsustainable land-management systems such as intensive slash-and-burn cultivation. This practice, also still performed in many other tropical regions, accelerates the impoverishment of soils and results in erosion, which is caused by shorter fallow periods (Metzger, 2002; Maass, 2008; Hohnwald *et al*., 2010). Shifting cultivation is also known as one of the major causes for tropical deforestation due to the conversion of natural forests into agricultural land (O'Brien, 2002; FAO, 2015). Between 2006 and 2010, a yearly average of 132,137 ha natural forests have been cut in Guatemala, which makes it the country with the highest deforestation rate in Central America (INAB, 2017). However, the ongoing conversion of forests into agricultural land and its intensive management are considered necessary to cover the food demand of a growing population (FAO, 2012). Up to now, only few studies concerning alternative agricultural systems such as AF explored the reality of rural smallholder households in Guatemala (Gillespie *et al*., 1993; Alwang *et al*., 2005; Maass, 2008; Berdegué & Fuentealba, 2011; Schmitt-Harsh *et al*., 2012). Therefore, this study aims to investigate the relationship between capital accessibility, institutions, and livelihood strategies. Especially we want to understand how governmental and non-governmental organisations impact on farmers livelihood strategies according also to the availability of capitals, and finally, how these factors influence farmers in the adoption and composition of AF system, the creation of sustainable livelihood, and the promotion of rural development in different regions. Our hypothesis is that different institutional structures influence farmers (i) in the adoption of different livelihood strategies, and (ii) in the protection of forests and ecosystem services.

2 Materials and methods

2.1 Study sites

We focus on the department of Alta Verapaz as study site because it is a little-known region with a long tradition of AF, i.e. in home-gardens and crop-growing systems of the Mayan culture (Horst, 1989; Maass, 2008). The region is located in the north central part of Guatemala towards the Petén humid tropical lowland (Fig. 1). The climate ranges from hot and humid in the lowlands to cold and humid in the highlands (MINECO, 2017). The region of Alta Verapaz has a population of about 1.25 million people and is one of the most densely populated departments of the country with approximately 145 inhabitants per km^2 (MAGA, 2015). About 80 % of the population lives in rural areas and about 90 % of it belongs to indigenous Mayan people of the Q'eqchi' and Poqomchi ethnic groups (Maass, 2008). Moderate to high food insecurity affects about 55 % of the households in Alta Verapaz (INE, 2011). The most cultivated crops of the region are maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), coffee (*Coffea arabica* L.), chili pepper (*Capsicum annuum* L.), cocoa (*Theobroma cacao* L.), vanilla (*Vanilla*

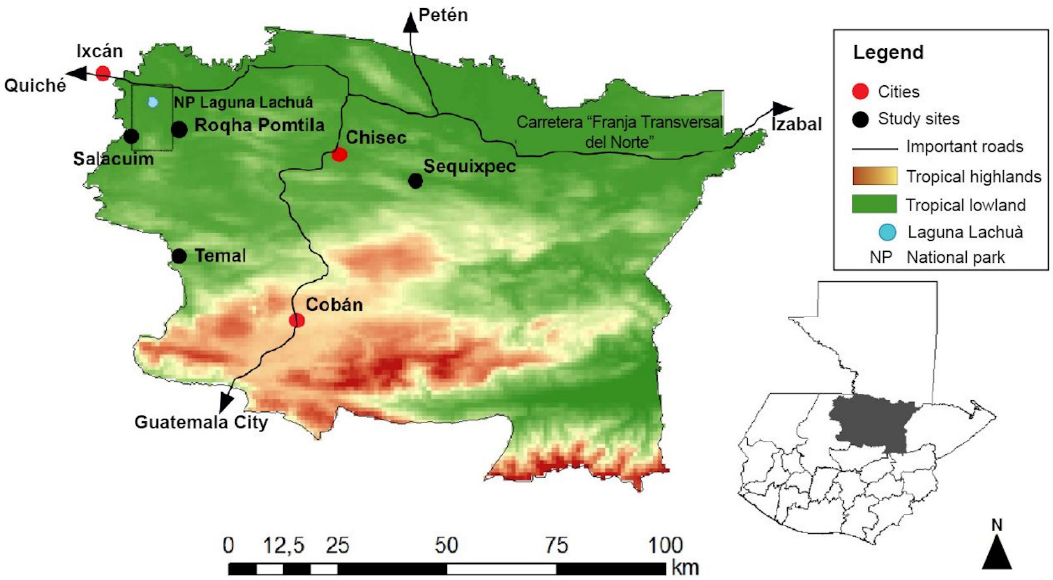

Fig. 1: *Location of the study sites in the department of Alta Verapaz, Guatemala.*

planifolia Plum. ex Mill.) and cardamom (*Elettaria cardamomum* L.) but also a high variety of fruit plants (e.g. *Musa sapientum* L., *Mangifera indica* L., *Persea americana* Mill.) and timber (MINECO, 2017). Subsistence farming forms the base of the rural economy in Alta Verapaz, as the majority of the Maya-Q'eqchi's livelihood is based on agriculture and largely dependent on the local natural resources (Maass, 2008). The predominating agricultural system throughout Alta Verapaz is called "*milpa*" which is a form of shifting cultivation traditionally practiced by smallholder farmers that inter-crop maize with different plants like vegetables, roots, and spices (FAO, 2007; Maass, 2008; Schmidt *et al*., 2012). The most common AF system found in farmer's households, is the home-garden system. This system hosts a high diversity of plants and is therefore a key aspect in the ecological and socioeconomic dimensions of rural communities, as it is an important source for household food security (Gillespie *et al*., 1993; Leiva *et al*., 2002).

An AF system, which has been widely adopted by farmers in Alta Verapaz, is the cultivation of cardamom plants using the natural primary or secondary forest as shaded-tree system (Maass, 2008). This is considered as one of the most productive tropical humid forest systems in terms of economic returns in the world (Murugan *et al*., 2008). Alta Verapaz is the major producer of cardamom accounting for 68 % of the total national production. According to Bonham (2006) who made a study in nine communities of the region, Cardamom generates about 50 % of the total income of smallholder households. Another upcoming AF system in the region is based on the cultivation of cocoa. This crop has been strongly promoted by national and international institutions (e.g. access to high yielding cocoa through CATIE) in the past decade in order to diversify income sources of farmers while protecting the high biodiversity present in the region (IUCN, 2014). This AF has been reintroduced by various rural development projects also to support the reforestation of deforested areas through the planting of local tree species and the addition of cocoa in the understory. In this way, reforestation becomes a complementary activity to the income-producing cocoa cultivation (Choco Guate Maya, 2017).

For our study, we selected four communities as case studies, mainly located in the north western part of Alta Verapaz (Fig. 1). Two of them, Salacuim and Roqha Pomtila, are part of the so-called Eco-region Laguna Lachuá. The communities were selected based on the (1) presence of AF with cardamom and/or cocoa and preferably other crops, (2) variability in socio-economic conditions and infrastructure between the case studies, and (3) the presence of institutions. The number of interviewed farmers in the communities varied based on their availability. Thus, eleven interviews were carried out in Roqha Pomtila and Salacuim, where we were supported by CONAP (National Council for Protected Areas) officers in reaching the farmers with AF. While another eight interviews took place in Sequixpec and Temal where our local guide supported us. For the investigation, we stayed for about a week in every community and went with the farmers to their AF plots were the interviews were held.

2.2 Interviews and analysis

Semi-structured interviews on AF systems were carried out in March 2017, supported by a questionnaire. Nineteen interviews were performed with farmers. The interviews focused on farmers in their role as key informants according to Liswanti *et al*. (2012). The questionnaire followed the concept of Sustainable Rural Livelihood (SRL), which assumes that every human being has access to different livelihood assets or 'capitals'. The term 'capital' refers to natural, human, social, financial and physical assets available to people that help to overcome vulnerabilities and convert these into different livelihood strategies together with institutional structures and processes in order to pursue a positive livelihood outcome (Carswell, 1997; Hussein & Nelson, 1998; Scoones, 1998; DFID, 1999; Ellis, 1999). Therefore, it included open questions about AF composition and management, role of institutions and cooperatives, local networks, additional income sources, and general motivation and constrains from the farmers' perspective on AF. On-site observations on infrastructure, community life as well as agricultural activities added to our analysis in each community. The livelihood capital analysis, based on the data gathered on the study sites (Fig. 1), permits a tentative picture of capital accessibility of the communities.

For further analysis, the local area measurement units "*manzanas*", "*cuerdas*", and "*caballerias*" have been converted to international valid measures of square meters and hectares as well as local weight units like "*libras*" and "*quintales*" that have been converted into grams and kilograms. The national currency Quetzales has been converted to US Dollars (US$) based on the exchange rate of 15 March 2017 given by the oanda platform (https://www.oanda.com/currency/converter). The interviews and field data have been analysed using the Qualitative Content Analysis (QCA), as this is one of the most relevant techniques in social sciences (Krippendorff, 2004; Mayring, 2010; Schreier, 2012; Rössler, 2017). The SRL framework represents the main categories while the subcategories are the results obtained from the smallholder survey. For the relative representation of the degree of capital accessibility in the investigated villages, a spider-chart diagram has been created.

3 Results

3.1 AF systems in Alta Verapaz

The interviewed farmers are all male Guatemalans, with a mean age of 49.6 years that are living in households composed by 6.7 family members on average. The average size of the nineteen investigated AF systems was 3.5 (SD 2.6) ha. The AF systems are exclusively agro-silvicultural systems that combine perennial plantation crops, i.e. cardamom, cocoa, and vanilla with trees on the same land unit. Nine AF systems had one singular cash crop while 10 AF combined two cash crops on one plot. Three farmers managed additionally a spatially separated AF system, i.e. apiforestry (with beehives for honey production), a milpa plantation with young reforestation, and a silvo-pastoral system with cattle and goats. Cardamom is the most common cultivated cash crop (73 %) followed by cocoa (52 %) and vanilla (21 %). Maize and beans are the main subsistence crops for Q'eqchi Mayas, therefore almost all farmers own a milpa field with a size ranging from 0.7–2 ha. Various subsistence crops have been found within AF which comprise bananas (*M. sapientum*), pineapples (*Ananas comosus* (L.) Merr.), different fruit trees (e.g. *M. indica*) as well as tubers (*Manihot esculenta* Crantz) (Fig. 2). In one AF system, honey collection has been found.

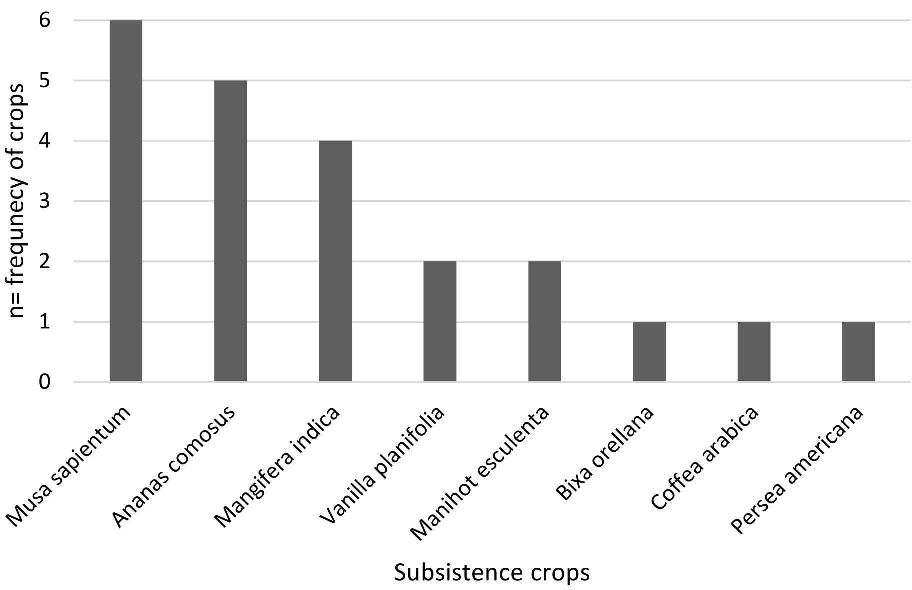

Fig. 2: *Subsistence crops cultivated in the investigated AF systems (n = 19) in Alta Verapaz, Guatemala.*

Table 1: *Production and yield data of cardamom and cocoa agroforestry (AF) systems.*

Characteristic	*Cardamom* ($n = 14$)	*Cocoa* ($n = 10$)
Harvest periods	Sep./Oct.–Mar./April	Dec./Jan.–May/June
Average field size	1.78 (SD 0.05) ha	2.6 (SD 0.08) ha
Average production per ha	755 (SD 0.02) kg	1,170 (SD 0.03) kg
Average market price per kg fresh weight	1.3 (SD 0.03) US$	1 (SD 0.06) US$

The main function of the trees of the investigated AF systems is to provide shade to cocoa and cardamom plants. However, 36 % of the farmers stated that trees carry out also a multiple function as a source for fuelwood, construction material, food provision, and as natural fertiliser (e.g. by leguminous trees).

Weeding is by far the highest investment in agriculture a smallholder farmer must face. Seventy-seven percent of the AF systems are weeded twice a year while 23 % are weeded three or more times per year. The weeding is carried out manually with a machete and the average costs of an employee are US$ 64 per hectare per weeding session. The weeded biomass is left in the AF and therefore reintroduced in the nutrient cycle as fertiliser while larger trees or shrubs, instead, are used as fuelwood. The beginning of the dry season in December and January is the most work intensive period of the year, as harvesting and weeding are overlapping and therefore require high labour input. Depending on the crop variety, the lack of agricultural income can last between two to six months.

About half of the farmers reported that their agricultural production relies on "what the earth gives", which means that they do not use any type of exogenous inputs such as industrial fertiliser or chemicals because they cannot afford it. At date, only three farmers were actively purchasing and applying organic fertiliser based on algae and fish products on their fields in order to increase the cocoa production. The leguminous tree '*madre cacao*' (*Gliricidia sepium* (Jacq.) Kunth ex Walp.), commonly applied as intercropping tree throughout the tropics (e.g. Kaba *et al.*, 2019), is used as natural fertiliser in two cocoa AF systems.

In all investigated cardamom AF systems, the crop was grown in the understory of reforestations or at the margins of natural forests and produced around 755 kg fresh weight of beans per ha (Table 1).

Farmers that work with cocoa stated that this crop is work intensive and requires a lot of attention and knowledge especially during the establishment in the first three years. Cocoa produces first benefits to farmers after three years of planting. All farmers that produce cocoa started this AF system through the initiatives and trainings of the Laguna Lachuá Foundation Fundalachuá. The NGO Fundalachuá has been established in 2007 thanks to the strong cooperation with the International Union for Conservation of Nature (IUCN) and the Ministry of Agriculture and Livestock (MAGA) in order to promote sustainable rural, economic and environmental development i.e. through the implementation of cocoa projects. Technical assistance for the cocoa plantations was offered by CATIE (Tropical Agricultural Research and Higher Education Centre), Fundasistemas and Choco Guate Maya whereas financial support came from the Swiss foundation ARGIDIUS.

All interviewed farmers reported that they cultivate at least five to six different cocoa varieties on the same cultivation, as it results in a better quality and aroma through the mixture and the costumers ask for it. On average, a farmer produces around 1,170 kg cocoa fresh weight per ha (Table 1).

3.2 *Capital accessibility in the farmers' communities*

Values for natural capitals are high in all four communities, showing therefore that natural assets are the most important basis for the farmer's subsistence (Fig. 3). Access to land and water is always available and ecosystem services of forest and agricultural systems are strongly represented in all four communities (Table 2). The maintenance of biodiversity is ensured in Salacuim and Roqha through the protection given by the National Park Laguna Lachuá, and in Temal thanks to a low-population pressure favouring widely undisturbed forest areas.

During fieldwork, various social activities within the four villages have been observed ranging from religious meetings, team sports, various celebrations, and other social events. Knowledge and labour exchange between smallholders have being widely observed showing that social capital is the second most important resource for smallholder families. Farmers help each other with weeding, harvesting, and tree felling as well as building construction and street maintenance. Farmer's cooperatives were present in the Lachuá communities, Salacuim and Roqha and supported by the local non-governmental organisation.

Regarding physical capitals there is a big lack of infrastructure in Sequixpec and Temal, as they are barely reachable by transportation, have no energy supply and few com-

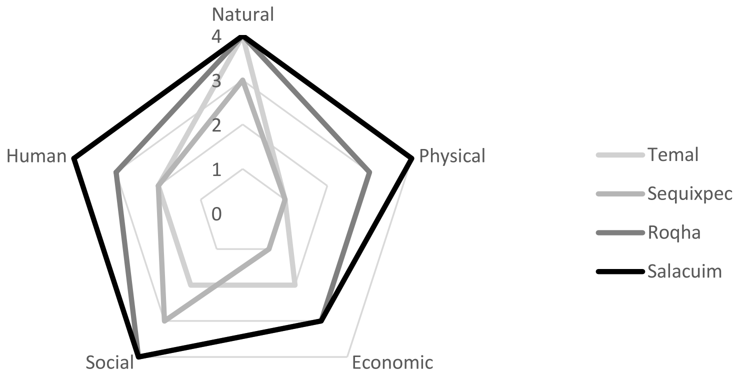

Fig. 3: *Capital accessibility spectrum of the four study sites represented as spider chart. The chart allows a direct comparison of the asset's availability and shows similarities and disparities in the respective communities. The values range from 0 to 4, where 0 means none of the criteria were accessible, while four means that all four criteria of a capital where available to the smallholder families and the community.*

Table 2: *Selected criteria for each analysed livelihood capital.*

Livelihood capitals	*Selected criteria*
Natural	Access to land and water; ecosystem services; biodiversity
Social	Rules and norms; cooperatives; exchange; social activities
Human	Skills and knowledge; training offers; education and health services
Physical	Water and energy supply; infrastructure; access to information
Economic	Bank loan; micro-credits; liquid assets; regular money inflows

munication opportunities. The Lachuá communities are instead well integrated with the national road network, local transport services and are even connected to the internet. These villages have also access to agricultural machinery and host a drying station for the cocoa fermentation as well as plant nurseries thanks to the help of the local NGO.

The lowest capital available to farmers are the economic capitals showing also large divergences between communities with (Salacuim and Roqha) and without (Temal and Sequixpec) governmental and non-governmental organisations. For farmers in Sequixpec, liquid assets are the only financial resources their livelihoods rely on. In Temal farmers applied for national reforestation incentives. Farmers in the Lachuá communities instead are favoured by the NGO presence and are well informed about financial support on forestry offered by the state. Most of the smallholders reported to have access to micro-credits with low interests provided by the farmers' cooperative and Fundalachuá, and bank loans are a common practice, too. These factors make them economically better-off, as both financial sources are missing in Temal and Sequixpec. Regular money inflows such as pensions, state-transfers or remittances are however, missing in all villages. The same pattern can be found in human capitals where again, Lachuá communities' benefit from institutional support. Nevertheless, promotion of agricultural knowledge, found in all four cases, is of fundamental importance for rural communities. Farmers rely on agriculture as subsistence, consequently knowledge and skills are transmitted to the community and family members since childhood. Agricultural trainings are offered in the Lachuá communities thanks to the institutional presence while Sequixpec and Temal lack on agricultural trainings offers, as there is no presence or collaboration with institutions. Three communities include an education infrastructure (i.e. primary school) and two medical services.

The interviews revealed three main vulnerability aspects that farmers face regarding their agricultural production. These are the effects of climate change such as droughts and shifts of the rainy season (37 %), soil degradation and subsequent lowered productivity (32 %), and unstable market prices of, in particular, cardamom (37 %).

3.3 *The role of institutions for transforming livelihood strategies*

Two institutions are playing a central role in the four analysed communities that have a direct effect on AF systems, i.e. the National Forestry Institute (INAB), at the national level, and the NGO Fundalachuá on a local level. These institutions revealed to be an important linkage between capitals and smallholders especially for economic, human and physical capitals, which is shown in Table 3. Fifteen farmers are members of Fundalachuá and/or receive financial support from INAB. Four farmers instead stated to get no kind of institutional support. Fundalachuá is active in Salacuim and Roqha (the Lachuá communities), and in other communities included in the 'Eco-region Laguna Lachuá'. One of the most important roles of Fundalachuá is to transfer and increase knowledge and skills on cocoa cultivation practices, offering financial help with micro-credits to farmers, and address their activities into a sustainable agriculture and responsible management of natural resources. In fact, an organic production of cocoa is mandatory for all farmers that want to be supported by Fundalachuá. This NGO offers free trainings (i.e. shade-trees' management, pruning, composting, cocoa fermentation and apiculture), field trips and favours experience exchange between farmers to promote a deeper understanding of AF. Forest management plans are also created together with professionals to support each singular farmer with the planning and maintenance of AF systems. The foundation supported the communities also in the creation of farmer's cooperatives i.e. ASODIRP situated in Roqha and KATBALPOM in Salacuim. These cooperatives unite all cocoa producers within and outside the communities in order to favour micro enterprising and marketing, achieve a higher and homogenous quality of cocoa beans, and generate sustainable income. This allows farmers to be more competitive on the international market, be conform to quality standard requirements and improve smallholder's business and administration skills, network abilities and independence. Furthermore, the NGO includes also eco-tourism projects and focuses on the promotion of female primary producers. Another important contribution of Fundalachuá to farmer's assets is the economic support. Micro-credits with low interest rates for a one-hectare cocoa plantation amount to around US$ 180 per year for three years.

The Guatemalan Forestry Institute INAB operates since 1996 nation-wide and is managed by an executive board formed by representatives of ministries, universities, NGOs and municipalities. Financial support for farmers comes from forest incentives paid by the Government of Guatemala. INAB´s role stands on monitoring and certifying plantations in order to comply with government requirements. The governmental contribution is given through incentives for reforestation, afforestation, AF and forest protection to smallholders, companies and associations who want to start such a project. There are three different incentive programs that apply depending from land size and outcome: The 'PROBOSQUE' program targets farmers who want to reforest a deforested area lager than 15 ha, 'PINPEP' for farmers with less than 15 ha land that want to start an AF or protect a part of forest and the 'PINFOR' that provides a professional management plan for farmers who own a reforestation plot. Eight farmers enrolled for such an incentive. They either implemented reforestations with high-value timber on previous milpa, cardamom, and pasture areas or decided to put their forest plots under protection. Farmers get a financial compensation of approximately US$ 270 for each hectare protected forest and an incentive of around US$ 250 per ha for afforestation during a period of 6 years. One successful example in Roqha, composed by a group of fifteen families (10 % of all community families), is protecting 120 ha privately owned natural forest, subsidized by INAB. The Lachuá communities are the ones which most take advantage of national and local support. Farmers in Temal applied for INAB incentives while any farmer from Sequixpec isn't using any kind of institutional benefit.

3.4 Livelihood strategies

Three livelihood strategy patterns have been detected which are (1) on-farm diversification supported by forestry incentives, (2) off-farm income and agricultural intensification and (3) migration (Table 4). On-farm diversification was found to be the most common subsistence strategy adopted by farmers, as it is present in 11 strategy portfolios. In fact, 65 % of the analysed AF systems combined trees with two understory cash crops, two are beekeepers and one hold cattle, the latter thus being a silvo-pastural system. Subsidised reforestation created additional income to these farmers by payments of the INAB in form of subsidies and incentives that promote reforestation and forest protection projects, a strategy found in Temal and Lachuá villages. In general, diversification was found in all portfolios on a subsistence-crop level, as all farmers grow milpas and home-gardens.

Off-farm income is pursued by six smallholders that stated to have an additional non-agricultural employment, e.g. in eco-tourism activities as a guide, in the National Park as guardian and as teacher in local schools. The same six farmers adopted the strategy of agricultural intensification, all of them were involved in cocoa production in the Lachuá communities. Intensification is supported through high-yielding cocoa varieties offered by Fundalachuá and CATIE and that are now independently reproduced by farmers in local nursery. Three cocoa farmers had between 10 and 20 employees and were additionally purchasing organic fertiliser. This fact distinguishes them clearly from the smallholders that diversify, as they rely mainly on family labour with an average of 3.3 (SD 1.6) people working on fields. Only two out of nineteen farmers, both living in Sequixpec, migrate temporarily for seasonal jobs to Mexico to earn extra money to sustain the household income.

Table 3: *Capital accessibility supported by Fundalachuá and the INAB in the four communities.*

Capitals	*Fundalachuá*	*INAB*
Natural	Start-up help and implementation support of cocoa AF, create access to high-yield crops and free seedlings, promote apiculture	Management support of re/afforestation and forest protection projects, enhance and maintain ecosystem services
Physical	Sponsored infrastructure used to collect, ferment, dry and store cocoa beans, but also bee-hives, function as source of information and technical assistance	Support with technical forestry equipment and machinery, source of information
Human	Organize trainings, field trips, experience exchange, create networks to costumers and give access to international market	Increase knowledge and skills about forestry and AF management practices
Social	Organize social activities, e.g. a cocoa festival	Support national networks between farmers
Economic	Offer micro-credits with low interest rates, develop marketing mechanisms and support commercialization of the product	Offer various incentives and credit programs, create an individual forestry management plan

Table 4: *Overview of livelihood strategies adopted by the interviewed farmers.*

Strategy	*No. of farmers*	*Definition and indicators*	*Source of income*
Agricultural diversification	11	Agricultural and crop diversification refers to the addition of new crops, cropping systems, and agricultural activities to farm production; this results in different returns from value-added crops with complementary marketing opportunities	Selling or subsistence use of agricultural products
Subsidised forestry	8	Planting trees on land that was covered by forest recently, protecting a forest area; this strategy refers to the application of INAB incentives for reforestation, forest protection and AF projects.	Subsidies and credits; long term income after logging
Agricultural intensification	6	Intensification aims to maximise crop production on land unit; led by capital investments and increased labour input	Increased agricultural output
Non-agricultural income	6	Widen income portfolio through off-farm activities; range from casual, part-time, unskilled works up to full-time employments that require a higher education	Daily wages, loans, pensions
Migration	2	Temporary, seasonally or permanently movement of people to another area or country to find work	Daily wages, loans

4 Discussion

Our results on capital accessibility showed a high access to natural and social capitals of farmers in the four analysed villages in Alta Verapaz. This reflects that farmers reciprocity, solidarity and community cohesion are important social pillars while property rights, functioning ecosystem and availability of natural resources are vital for a livelihood based on agriculture. In order to keep a high accessibility to natural capital, the promotion of AF systems that support the self-regulation of pests and diseases, conservation of biodiversity and soil fertility, as well as climate change mitigation and adaptation is fundamental (Schneider *et al.* 2016). By comparing the main vulnerabilities of livelihood stated by the interviewees (i.e. climate change, loss of production, and soil fertility) it becomes obvious that AF systems can buffer negative impacts caused by climate change and unsustainable land-use. The strength of AF lies also in the ability of making efficient use of natural resources for crop production in a way that natural capitals are maintained on the long term and for future generations which is in line with sustainability (Buck *et al.*, 1998). The availability of resources and financial profit of future generation was also stated by many farmers and institutions as common reasons for the implementation of AF systems and reforestation.

The value for physical capital was higher in the Lachuá communities, as these villages are favoured by their location being next to an important connection street while Temal and Sequixpec are far more isolated from larger agglomerations and transport is difficult. The shortcoming of adequate infrastructure and generally low physical capital causes slow development of agricultural innovation and market accessibility of rural areas (Alwang *et al*., 2005) which was also reported by our interviewees in Temal and Sequixpec. Thus, the structural advantages facilitate substantially the production, transport and market accessibility of the Lachuá villages. A common hurdle stated in the interviews is the unfavourable accessibility to market and middlemen as well as the difficult transport of the harvested crops. Nevertheless, the villages are not comparable as the availability, quality and provision of physical capital goes beyond institutional influence.

Human but especially economic capitals are hardly available in communities without organisational structures such as Sequixpec and partially Temal. These capital lacks have a negative effect on the creation of a stable livelihood basis of smallholder families and for the conservation of tropical forests (Steffan-Dewenter *et al*., 2007; Armengot *et al*., 2016; Rahman *et al*., 2017a). Low human capital rates end up in low household adaptability to vulnerabilities, as farmers cannot provide the necessary knowledge to manage AF systems properly (Schmidt *et al*., 2012; Rahman *et al*., 2017b) and eventually force farmers to abandon agriculture if they do not manage to recover from shocks (Schmidt *et al*., 2012). Whereas studies on AF managed by African and Asian farmers, state that the lack of financial capital was the main factor that constrains initial investments in AF (Rahman *et al*., 2017b,a). Furthermore, the limited range of capitals tend to lead to an overexploitation of natural resources, as they often represent the only liquid assets and energy source of farmers (FAO *et al*., 2011). These facts have been confirmed looking at farmers in Sequixpec, which are more likely to migrate, make use of unsustainable agricultural practices such as removal of shade trees from AF systems and cut trees at the forest boundaries. These results are underlining the urgency to provide institutional assistance, technical and market information in communities were governmental and non-governmental support are missing.

Our study underlines the key role of institutional support and policy incentives, promoting the access for farmers to various human and financial assets (DFID, 1999). Financial support like incentives, micro-credits, subsidies, and tax alleviations can favour the initial conditions to motivate smallholder farmers and other land users to adopt and continue with AF practices (FAO, 2010). Farmers in Roqha Pomtila and Salacuim have a considerable range of financial assets available thanks to the local NGO that allows accessibility to economic assets through a start-up package based on micro-credits, free timber tree seedlings and free high-yielding cocoa seedlings. Additionally, human capital is enhanced by training offers, infrastructure and networking activities. An important aspect is also the cooperation of Fundalachuá with international companies that buy organically produced, high-quality cocoa at fair and stable prices. Certification programs for shade-grown cocoa may provide socioeconomic incentives to prevent unsustainable intensification (Torquebiau, 1992; Steffan-Dewenter *et al*., 2007; Bisseleua, *et al*. 2009). The benefits of INAB are visible in Temal and Roqha where in both cases a group of local farmers decide to apply for the PROBOSQUE program.

The positive effect of Fundalachuá and INAB can be detected also in the livelihood strategies of farmers who beneficiated from their support. Generally, the predominant livelihood strategy within the study is represented by on-farm diversification. That's not surprising, as the strength of AF systems is found in their ability of diversify agricultural production and therefore enhance the income stability and flexibility to changing markets while diminishing the probability of crop failure (Ellis, 1999; Schmidt *et al*., 2012; Vaast & Somarriba, 2014; Mbow, 2015; Tiwari *et al*., 2017). Studies on cocoa AF report that the economic return of a diverse AF system by cumulative yields of all products harvested is significantly higher compared with monocultures (Steffan-Dewenter *et al*., 2007; Schneider *et al*., 2016). From an ecological point of view diversification in AF systems can sustain the ecosystem service provision (Kremen *et al*., 2012), is able to increase adaptability of agro-ecological systems to negative external factors (Henry *et al*., 2009) and that well managed shade trees can sustain biodiversity and maintain high levels of ecosystem functioning (Steffan-Dewenter *et al*., 2007).

Farmers that have an additional off-farm income have enough monetary resources to purse higher quantities of external inputs and hire more employees. A similar result has been found in a study on cocoa AF in Cameroon where farmers either invested in diversification or consequently get additional revenues and food security from AF by-products while others implemented more specialized AF and invested more in higher cocoa yields and income (Saj *et al*., 2017).

5 Conclusion

Our study underlines and confirms the importance of institutions for the promotion of AF and livelihood sustainability in rural areas of Alta Verapaz. AF systems supported by policies and incentives constitute a valuable solution for smallholder families to achieve a stable and resilient livelihood, ensures permanent income source and protect the forest and natural resources on the long-term. Through the promotion of cocoa AF and forestry subsidies, smallholders' livelihood sustainability increased through the favoured on-farm diversification and additional financial security, two factors that can challenge temporary shortcomings, negative natural impacts and unfavourable market conditions. Consequently, we derive the following recommendations, also valid for other tropical rural areas:

– Promote information on governmental forestry incentives, local or regional AF projects and highlight financial benefits of AF in communities with high migration and deforestation rates; favour community reforestation, forest protection and AF initiatives by involving municipalities, NGOs, local cooperatives and private companies in order to create awareness for the environment and the importance of ecosystem services in forest areas;
– focus on trainings that promote innovation, diversification and adaptability of agricultural systems and AF, e.g. through organic management systems, composting and organic fertilisation, natural pest and weed control systems, intercropping and animal husbandry in AF; widen this offer to young and old, male and female farmers including also trainings on processing crops;
– favour the creation of farmer's cooperatives to overcome financial shortcomings, enhance the competition and independence from middlemen and market prices; widen communication and networks to other cooperatives on a regional level and built up relationships to business companies for organic and high-quality cocoa.

Competing interests

The authors declare that they have no conflict of interest.

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