Sustainable coffee farming framework: a chain view

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SUMMARY

This study has adapted the Sustainable Livelihood Framework (SLF) to comprehend and compare the sustainability of different green coffee farming systems. The SLF is a people-centred framework designed for a better understanding of the complexities of poverty. The framework presents the main influencing factors for the people's livelihood and it emphasises their multiple interactions.
The resulting framework, called Sustainable Coffee Farming Framework (SCFF), has been applied in its completeness to gain knowledge on how the supply chains and the external environment are influencing the coffee farmer and consequently the sustainability of coffee farming. The SCFF is made of the following components: a) the vulnerability context; b) the coffee farmer assets; c) the transforming structures and processes; d) the coffee farming strategies and e) the coffee farming sustainability outcomes.
An in-depth multi-case research analysis has been carried on in three very different farming systems: 1) Brazilian full-sun coffee farming system; 2) Guatemalan shaded coffee farming system and 3) Indian shaded multi-cropping system. Questionnaires have been submitted and farming data have been gathered on the field for all the three cases.
The research has highlighted the need for an improvement of the human capitals in Brazil towards a more progressive view of the environmental and social issues associated with the coffee production. In Guatemala it has been found that the young generations should be the target of the investments to adapt the coffee business to a changing scenario. Finally, India has been found to be lacking of physical assets and human assets; it is urgent to invest in technology innovation and in attracting people to stay in rural areas.
The SCFF can be used in the future as a supporting tool to invest in the improvement of the farmer's capital assets for a more sustainable coffee farming (resilience to the supply chain and environmental influences). It has therefore the potential to become a practical governance tool for sustainable supply chain management in the coffee sector.

INTRODUCTION

Sustainability is somehow a misused and abused term. A milestone definition has been given in 1987 by the report of the World Conference on Environment and Development (WCDE), also known as the Brundtland Commission. The report of the Brundtland Commission interprets sustainable development as the present economical exploitation of any kind of resource in a way that the same resource will be equally available for the future generations. After that, the definition of sustainable development has been expanded to include the ideas of fairness and interdependence, not only between generations but also between the countries and peoples of the globe (Brown L.R. *et al*., 1995). It is therefore clear that, in global businesses, the adoption of fair practices strongly contributes to the long term sustainable development of the businesses themselves. Sustainability recognizes also the interdependence of ecological, social and economic systems, the three pillars of sustainability (Hutchins M.J. and Sutherland J.W., 2008).

Because of this complexity, sustainable supply chains decision-makers are often limited in what they can know (bounded rationality) and thus rational calculations cannot guarantee optimal solutions (Matos S. and Hall J., 2007).

In light of the current scenario of climate change and global population growth, the concept of sustainable agriculture, meant as the ability of agro-ecosystems to remain productive in the long term (van der Werf H.M.G. and Petit J., 2002), has become more and more important. Sustainable agriculture has been defined by Lewandowski *et al* (1999) as the management and utilization of the agricultural ecosystem in a way that maintains its biological diversity, productivity, regeneration capacity, vitality and ability to function, so that it can fulfil, today and in the future, significant ecological, economic and social functions at the local, national and global levels and does not harm other ecosystems.

There is a wide range of different Arabica coffee agro-ecosystems varying from full-sun coffee mono-culture agro-ecosystems to shade-grown coffee mono-culture or poly-culture agro-ecosystems. The farmer's decision about the agricultural strategies to adopt, including the choice of the coffee agro-ecosystem type, is the result of the continuous and complex interactions of a number of internal and external factors. The arising question is whether the currently managed coffee agro-ecosystem is the most sustainable one for that specific reality at that specific time or differently there are better alternatives, changes or improvements to be possibly done. There is the need to improve the methodology to understand measure and compare the sustainability of coffee farming systems, their dynamics and mechanisms in response to different external and internal factors. The objective of this research is the design of a methodological framework to become a living tool useful for decision-makers in the private and public sectors to invest and work towards more sustainable coffee supplies.

The starting point of this research has been the analysis of the existing frameworks useful for this research objective. The analysis has found that the Sustainable Livelihood Framework (SLF) is the more appropriate framework to understand the three-dimensional, dynamic and complex sustainability concept. The SLF is the flexible analysis component of the Sustainable Livelihood Approach created by the UK Institute

of Development Studies. It is a non-linear people-centred analysis to derive a set of guidelines and principles in order to address and fight poverty. The Framework is composed of the following parts (see Figure 2): 1) The Vulnerability context; 2) The Livelihood assets; 3) The Transforming structures and processes; 4) The Livelihood strategies; 5) The Livelihood outcomes.
The framework has been widely used to design multiple entry points for investment strategies or policies for sustainable development aimed at poverty reduction or resource management improvement in the long term (Brock K., 2000; Nicol A., 2000; Scoones I., 2000; Allison E.H. and Horemans B., 2006). The framework has been used to assess the impact of fair trade initiatives on small farmers (Utting, 2008). This framework has never been used for understanding the sustainability of farming with a supply chain/business view. In the following paragraph, the case of the global Arabica coffee supply chain is presented.

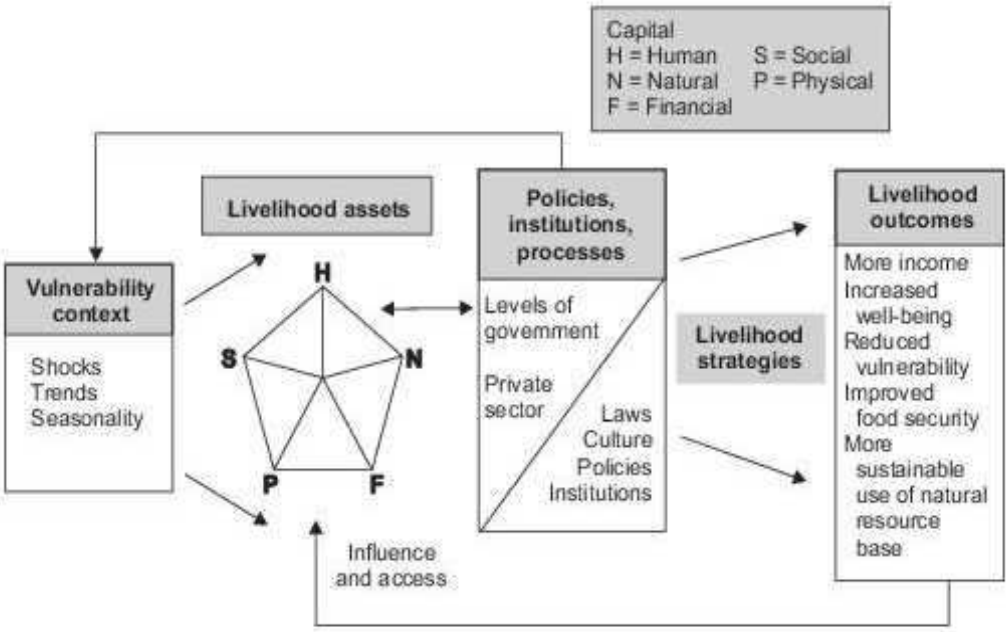

Figure 2: The Sustainable Livelihood Framework

The research has then adapted the design of the SLF to deeply understand the sustainability of different coffee farming supplies. The newly designed framework, called Sustainable Coffee Farming Framework (SCFF), has been tested using the case study methodology in three different coffee agro-ecosystems in three different coffee producing countries: 1) Brazilian full-sun coffee farming; 2) Guatemalan partially shaded coffee farming and 3) Indian highly shaded multi-cropping system.
The SCFF has underlined differences among the farming systems in terms of outcome indicators and emphasized the main interacting factors. The SCFF analysis has been used as a decision-making tool to find the most important areas to invest towards improving the sustainability performance of coffee farming.

MATERIALS AND METHODS

Each part of the SLF and the interactions among the parts have been adapted to coffee farming and coffee supply chains using an analysis of the existing scientific literature, a review of the recent news articles and collecting experts' interviews. Afterwards the newly designed sustainable coffee farming framework (SCFF) has been tested with three case studies. Three medium-big case-farms (more than 150 hectares) representing three different farming strategies have been selected: full-sun coffee farming in Brazil, partially shaded coffee farming in Guatemala and highly shaded multi-cropping system in India. The three cases represent different degrees of farming intensity: from high intensity coffee farming in Brazil, to medium intensity coffee farming in Guatemala to low intensity farming in India. The farming intensity can be defined by the intensity of land use (planting density, shading and crop specialization), the degree of agricultural technology adoption and the amount of chemical inputs use for crop production.

The three selected case-farms are located in three well-know producing areas: Cerrado Mineiro (Brazil) (18°56′38″S, 46°59′34″W), Fraijanes (Guatemala) (14°9′22″N, 90°24′25″W) and Coorg (India) (12°42′08″N, 75°73′97″W).

The research has considered more interesting to test the new framework using medium-big farms as they are more exposed to global trade.

The three case-farms have also been selected for the high quality profile in terms of data record and in terms of agronomical knowledge in order to facilitate the data collection and to test the best-in-class for each farming model. In each case-farm a one hectare experimental area has been chosen for field data collection. The selection criteria of the experimental areas have been: a) presence of coffee plants producing for at least three years and b) a maximum slope of 20%.

The available, common and relevant assets for each category have been defined using interviews with experts and reviews of the literature. The existing transforming structures have been determined by the analysis of the global coffee supply chain actors using various expertises. The transforming processes relevant for the sustainability of the coffee farming have been analyzed through the literature review. In each selected farm-case questionnaires have been submitted and one-to-one interviews have been conducted with the farm owners and farm managers at the end of the coffee season 2009/2010. The questionnaire has been directed to understand the farmer's capital assets as well as the transforming structures and processes each coffee farming business is exposed to. The vulnerability context has been structured through the PESTEL analysis using experts' interviews and latest news media review. The coffee farming strategies have been defined by the degree of farming intensity: crop specialization or diversification, shading intensity, planting density as well as chemical and technological input use. The coffee farming outcomes have been analyzed through a set of twelve specifically designed strategic indicators: 4 environmental indicators, 4 economic indicators and 4 social indicators. The 12 strategic indicators have been identified from selected principles and criteria following the MESMIS 6 steps framework (Lopez-Ridaura *et al.*, 2002; Van Cauwenbergh *et al.*, 2007). The indicators have been structured as multi-dimensional index, named AGROECO*SPA (Agro-Ecosystem Sustainability Performance Assessment), to measure and visualize the sustainability performance.

RESULTS AND DISCUSSION

The Sustainable Coffee Farming Framework – SCFF – is shown in Figure 3.

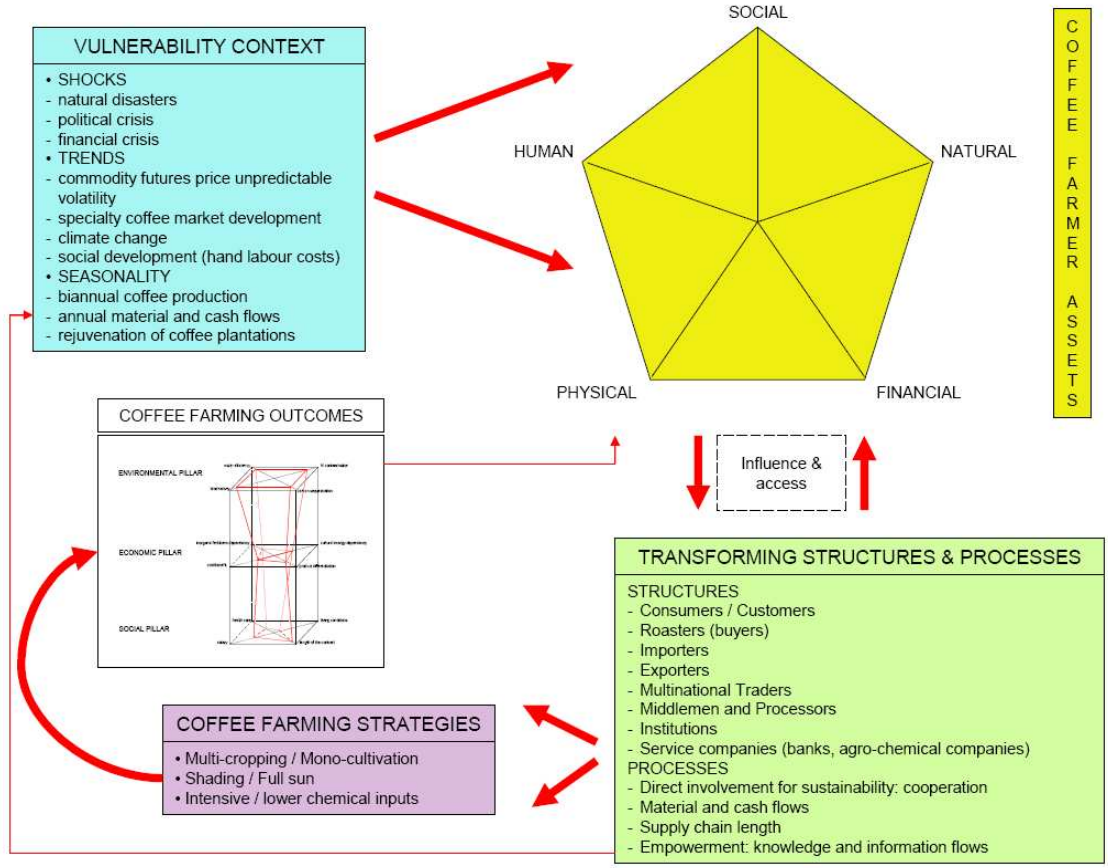

Figure 3: Sustainable Coffee Farming Framework (SCFF)

The global vulnerability context of the coffee production has been analyzed taking into consideration the most important contextual features. In Table 1 the relevant vulnerability context issues are reported.

Factors	***SHOCK***	***TREND***	***SEASONALITY***
Political	Political crisis	No relevant issues	No relevant issues
Economic	Financial crisis	Commodity futures price volatility Specialty coffee market development	Annual material and cash flows
Social	No relevant issues	Social develop. / generational change	No relevant issues
Technological	No relevant issues	Agricultural technology / crop shift	Biannual production
Environmental	Natural disasters	Climate change	No relevant issues
Legal	Legislation change	No relevant issues	No relevant issues

Table 1: PESTEL analysis of the relevant vulnerability context issues

The available coffee farmer assets, which are also common to all coffee growers around the world, are listed in Table 2.

Social	***Natural***	***Financial***	***Physical***	***Human***
Efficiency of national/regional coffee organization	Water access	Credit availability	Farm roads and vehicles	Green culture
Membership to cooperative/association	Soil fertility	Savings level	Energy availability	Knowledge of sustainable farming
Contacts with other coffee growers	Land adaptability	Sales time	Equipments (machineries and milling)	Availability of professional labour
Direct contacts with exporters/roasters		Income differentiation	Warehouse	Availability of hand labour
		Hedging tools	Communication	

Table 2: List of available and common coffee farmer capital assets

PROCESS	***Literature references***	***DESCRIPTION***
Cooperation	Beherens *et al*., 2006	Cooperation means direct involvement. The dedication for sustainability and the monitoring of the sustainable coffee supply chain are fundamental for sustainable resources exchange
Material and Cash flows	Hinterberger F. *et al.*, 1997 Hutchins M.J. and Sutherland J.W., 2008	These are the main tangible flows along the supply chain. Coffee is a renewable resource that must be used according to its regeneration rate. To generate a cash return, the farmer must use not only renewable resources, but also the non-renewable resources and the assimilative capacity of the ecosphere. The resources are called natural capital. The devaluation (or depreciation) of natural capital is incompatible with non-declining well-being.
Knowledge and Information flows	Gereffi G., 1999 Bitzer *et al.*, 2008 Seuring S. and Müller M., 2008	These are very important intangible flows. Participation in global commodity chains is a necessary step for industrial upgrading. Knowledge can become a powerful competitive weapon. Vertical partnerships present in the coffee supply chain aim at promoting sustainable production, building producer capacity, stabilizing producer environment and creating market access. Partnerships based on knowledge and information flows can actually empower other chain actors next to the lead firms (or focal companies). Nevertheless, most of the existing partnerships have used the word “empower” in the meaning of “enable”. The producer empowerment can be reached through deep producer market standards knowledge and the ability to meet them spontaneously.
Supply chain length	Vachon S. and Mao Z., 2008	It represents the distance between the customers (markets) and the suppliers. The proximity between these two actors is a characteristic of supply chain strength. Sustainability improves as supply chain strength increases and therefore as supply chain becomes shorter.

Table 3: List of relevant and influencing transforming processes for coffee farming

The transforming structures are all the possible existing coffee supply chain actors. The transforming processes can exert negative or positive pressures on the coffee farmers.

The relevant processes influencing the sustainability performance of coffee farming are delineated and described in the above Table 3.The interactions among the vulnerability context, the capital assets and the transforming processes are very important and complex parts of the framework. In order to comprehend the interactions, these are resumed and explained in Tables 4 - 5.

PROCESS	***Interaction with the capital assets***
Cooperation	Positive correlation with the human, social and financial assets. The human assets are improved as a consequence of a better monitoring of sustainable coffee farming. The social assets are stimulated by the possible vertical and horizontal contacts resulting from the direct involvement. The financial assets are improved as a consequence of a better cost analysis.
Material and Cash flows	Positive correlation with the financial and natural assets. The natural assets are positively correlated with a cash flow rewarding the real value of the materials used for production. The financial assets are improved as a consequence of a long term sustainable financial balance.
Knowledge and Information flows	A clearly positive correlation with the human and social assets.
Supply chain length	Positive correlation with the financial (less dispersed value) and social assets (stronger networking).

Table 4: Relationships between the transforming processes and the capital assets

PROCESS	***Interaction with the vulnerability context***
Cooperation	It reduces the risk and impact of financial crisis, market price volatility, climate change and social growth. It facilitates the specialty sector participation. It is positively correlated with biannual production and plant rejuvenation.
Material and Cash flows	They reduce the impact and the risk of a financial crisis.
Knowledge and Information flows	They have a beneficial effect on all the trends and seasonality.
Supply chain length	It allows to catch the opportunity of a growing specialty coffee market and to reduce the negative impact of the gaps between the annual material and cash flows.

Table 5: Relationships between the transforming processes and the vulnerability context

The sustainability of the transforming processes can heavily influence the sustainability of farming strategies. Strategies are oriented by the farmers mainly to satisfy the economic viability and to attend the social standards required by the national labour law, whereas only some of them tend to satisfy a virtuous environmental protection too. This can lead to more marked differences among farms in the environmental system respect to the economic system. This does not mean that there cannot be evident differences for the economic or social outcomes among different-strategy farms. Nevertheless, this might be caused more by lacking assets, negative processes, unintentional wrong strategies, side effects or by a combination of these. There is an asymmetry between the environmental system and the economy (Málovics *et al*., 2008). The suitability of the chosen farming strategy can be assessed with the measurement of the coffee farming outcomes. As mentioned before, the sustainability level of the outcomes can be measured through key sustainability performance indicators. These indicators will not be detailed in this paper.

The results of the framework tests, obtained with the three cases during the year 2009, are given in the paragraphs below.

High farming intensity: the Brazilian case

The pentagon in Figure 4 is the result of the analysis of the Brazilian farmer's capital assets.

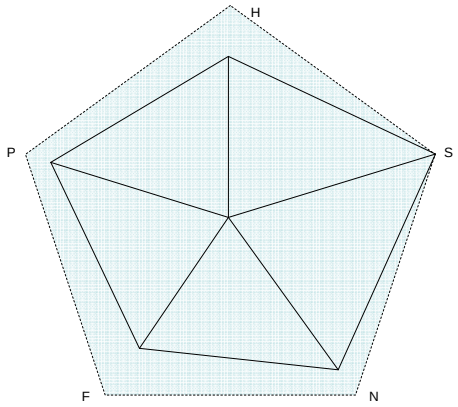

Figure 4: The Pentagon Capital Assets of the Brazilian Coffee Farmer

In Table 6 the results of the analysis are given.

Cooperation	Supply chains 1 and 3 involve the farmer into training programmes and stimulate him towards sustainability. Supply chain 2 is not working in cooperation with the farmer nor is it attempting to stimulate the sustainability of coffee farming. 70% of the coffee is sold by the farmer in structures promoting human, social and financial capitals.
Material and Cash flows	Supply Chain 1 is directly stimulating the environmental management improvement and the economic viability with a higher and stable price for better natural resources exploitation. Supply Chain 3 is compensating the natural resources use with a competitive and long term price, stimulating the economic viability but not the environmental management. Supply Chain 2 is not compensating the resource exploitation and is not stimulating a better environmental management nor the economic viability of coffee farming. Supply Chain 3 is also improving the market volatility. 70% of the coffee is sold by the farmer in structures promoting the financial asset. 40% of the coffee is sold by the farmer in a structure stimulating a better environmental management. 30% of the coffee is promoting the market volatility tend.
Knowledge and Information flows	Information is practiced by all the supply chains. Knowledge is spread only by Supply Chain 3.
Supply chain length	Supply chain 1 and 3 have 3 actors after the farmer and before the consumer. Supply chain 2 has got 4 actors before the consumer.

Table 6: Analysis of the transforming processes: Brazilian case-study.

The centre of the framework is the analysis of the farmer's assets and their interactions with the other components of the framework (Figure 5): vulnerability context and transforming processes. The financial asset is the weakest. The external environment is

not stimulating the substantial reduction of the financial asset in the long-term. Moreover, the farmer owns the key financial assets (hedging tools and specialty sector participation) to contrast the negative pressure of the external environment and to benefit from the positive pressure. Nevertheless, the farmer is concentrated to continuously foster the financial asset mainly by altering two other assets: the human (reducing labour) and the natural assets (exploring natural resources). Some of the transforming structures are working to improve the knowledge and the information along the supply chain (human capital). Only 40% of the product is sold directly under the influence of an environmental code; therefore, protecting the natural asset from a possible abuse. None of the supply chains is working towards the promotion of an environmental culture change.

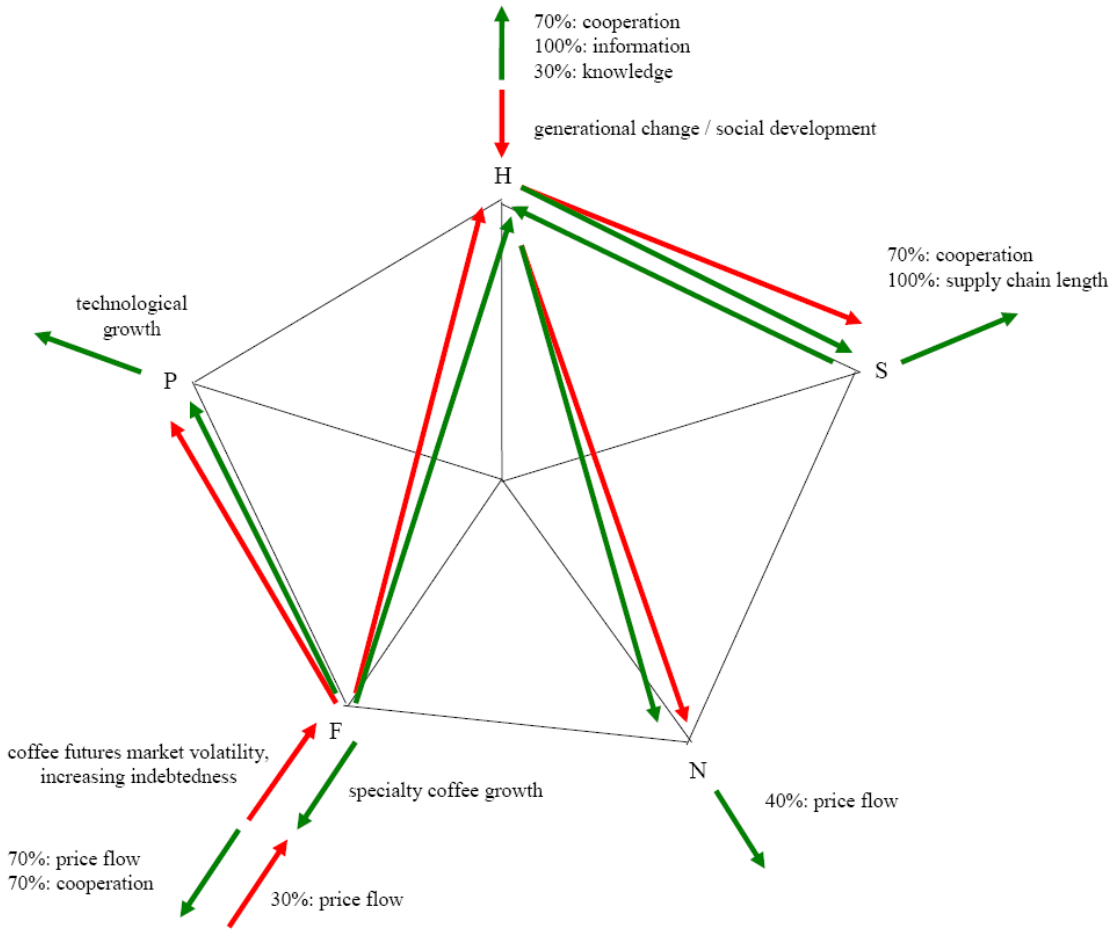

Figure 5: The Brazilian farmer's assets and their interactions

The Brazilian coffee farmer's strategy is the consequences of the objective of improving and preserving mainly the financial capital. The risk that arises from this analysis is a possible natural and human resources decay due to their unsustainable management. This is a consequence of the scarce importance given by the farmer to preserving the human and natural assets.

Medium farming intensity: the Guatemalan case

Figure 6 shows the pentagon of the Guatemalan farmer's capital assets.

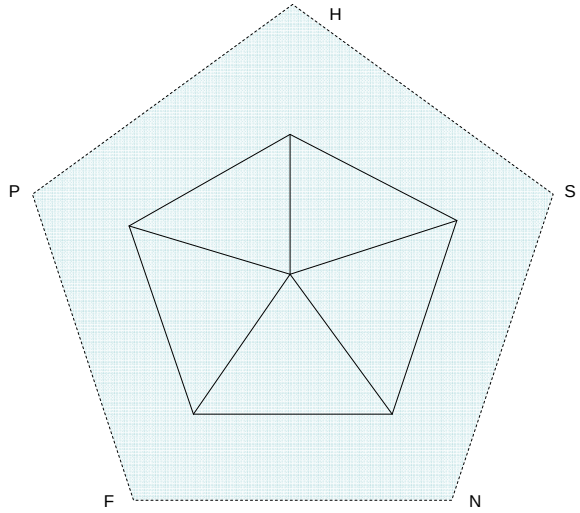

Figure 6: The Pentagon Capital Assets of the Guatemalan Coffee Farmer

In Table 7 the results of the analysis of the transforming structures are given.

Cooperation	Supply chain 1 stimulates the farmer's knowledge. Supply chain 3 is cooperating with the farmer to stimulate the sustainability of coffee farming. Supply chains 2 and 4 are not involved into improving the sustainability of the coffee farming. 60% of the coffee is sold by the farmer in structures promoting human and social capitals.
Material and Cash flows	Supply Chain 3 compensates the natural resources use with a competitive and long term stable price, stimulating the economic viability but not the environmental management. Supply Chain 1, 2 and 4 are not compensating with the price stability the right resource exploitation in the long term and are not stimulating a better environmental management or the economic viability of coffee farming. Supply Chain 2 is also improving the market volatility (trend). 30% of the coffee is sold by the farmer in structures promoting the financial asset. 30% of the coffee sales promote the market volatility.
Knowledge and Information flows	Information is practiced by supply chains 1, 2 and 3. Knowledge is spread only by the National Coffee Association, not by the supply chains.
Supply chain length	Supply chains 1 and 3 have 3 actors after the farmer and before the consumer. Supply chains 2 and 4 have 4 actors after the farmer and before the consumer.

Table 7: Analysis of the transforming processes: Guatemalan case study.

Figure 7 illustrates the analysis of the farmer's assets and their interactions with the other components of the framework. The Guatemalan coffee farmer does not have markedly stronger assets. The vulnerability context is not significantly influencing the financial asset. Indeed, the volatility of coffee prices is well balanced by a growth in the specialty coffee sector and by a temporary strong market. Nevertheless, the climate change could reduce the natural and physical assets. The farmer does have a particular key asset to contrast the negative pressure of climate change, the green culture asset. The farmer has

chosen to shade the coffee trees and this is a good climate change mitigation strategy. The difficult generational change poses a threat on the human assets. The transforming processes are just slightly enriching the human and social assets through cooperation and information sharing. Nevertheless, none of the supply chain's transforming structures is investing in knowledge.

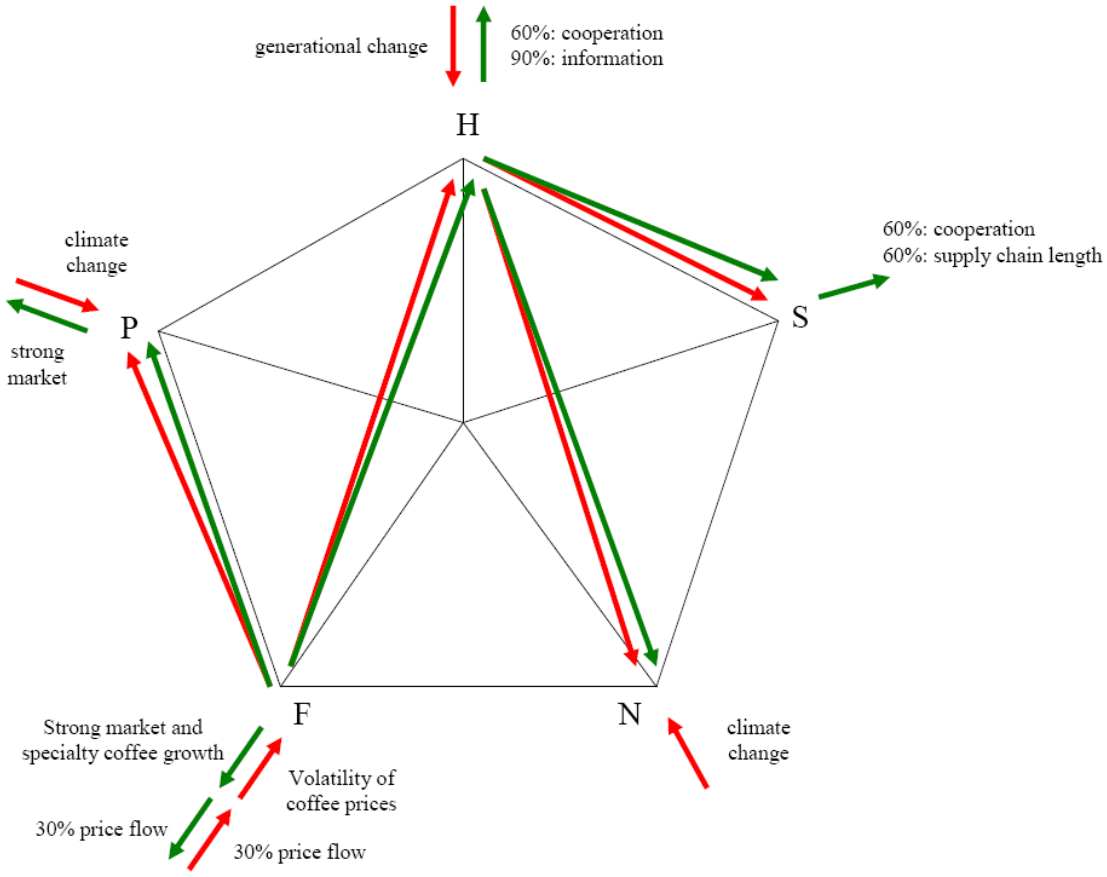

Figure 7: The Guatemalan farmer's assets and their interactions

The Guatemalan coffee farmer's strategy is the consequences of a mix of green culture and orientation to maximise the financial capital. The risk that arises from this analysis is that the difficult generational change could reduce the key asset of green culture in the future, therefore reducing the resilience to climate change effects.

Medium-low farming intensity: the Indian case

The Indian farmer's capital assets are represented in Figure 8:

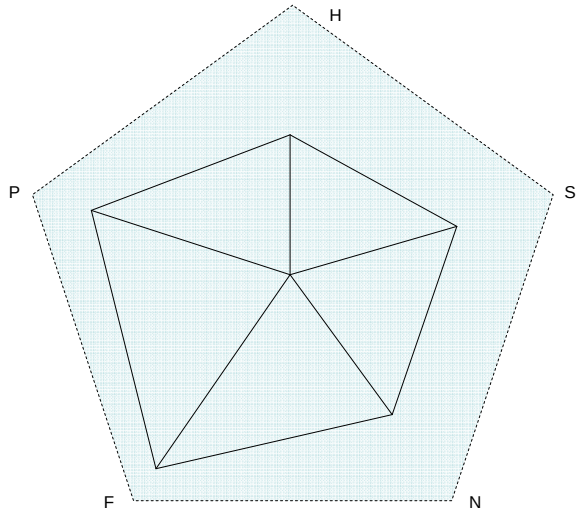

Figure 8: The Pentagon Capital Assets of the Indian Coffee Farmer

Table 8 resumes the analysis of the transforming structures.

Cooperation	Supply chains 1 and 3 involve the farmer into training programmes to stimulate him towards sustainability. Supply chain 3 is also working directly in cooperation with the farmer attempting to stimulate the sustainability of coffee farming. Supply chain 2 does not stimulate the sustainability of the coffee farming. 50% of the coffee is sold by the farmer in structures promoting human and social capitals.
Material and Cash flows	None of the supply chains is compensating the natural resources use with a competitive and long term stable price. Supply Chain 3 is indeed compensating with the price stability the economic viability of coffee farming. Supply Chain 2 is also improving the market volatility. 30% of the coffee is sold by the farmer in structures promoting the financial asset. 50% of the coffee is promoting the market volatility tend
Knowledge and Information flows	Information is practiced by supply chains 1, 2 and 3. Knowledge is spread only by Supply Chain 3.
Supply chain length	Supply chains 1 and 3 have 3 actors after the farmer and before the consumer. Supply chain 2 has 4 actors after the farmer and before the consumer.

Table 8: Analysis of the transforming processes: Indian case study.

The negative pressure for the increasing hand labour scarcity is eroding the farmer's human assets. These assets are not resilient to this negative pressure. The pressed human assets are not supported by strong social assets. The financial assets are under pressure for the increasing commodity market volatility and for the noted trend of shifting from Arabica coffee to Robusta coffee cultivation, posing the farmer even more exposed to the price volatility. Represented in Figure 9 is the analysis of the farmer's assets and their interactions with the other components of the framework: vulnerability context and transforming processes.

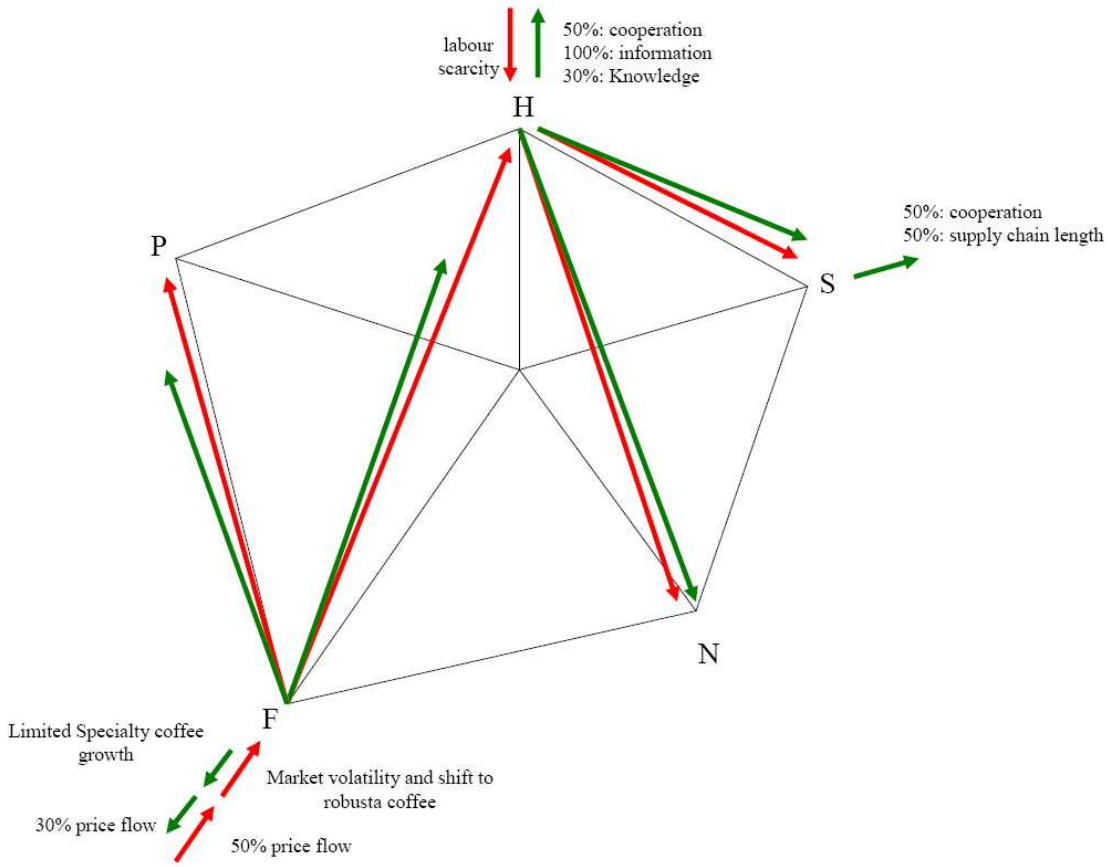

Figure 9: The Indian farmer's assets and their interactions

The Indian coffee farming strategy is a direct consequence of the human assets of green culture and product differentiation. This has positively contributed up to now to strengthening the financial assets. Nevertheless, a marked and continuous negative pressure on the financial assets could stimulate the reduction of the human and physical assets too. In the long term we could also assist to an increasing risk of erosion of the natural assets, which are not positively stimulated by the vulnerability context and the transforming processes.

CONCLUSION

In conclusion, the Sustainable Coffee Farming Framework has proven to be a useful sustainable coffee supply chain management tool. The analysis of the three case studies has helped to discover the most important risk areas for a sustainable development of the coffee farming business. This is the starting point to select the high-priority areas of investment for improving the sustainability performance of coffee farming. In Brazil, it has been found that the risk of eroding the human and the natural assets poses a threat on the sustainability of the coffee farming. It is therefore recommendable to invest in improving the human assets directly or indirectly through the social assets. The focus should be the promotion of a more advanced and progressive environmental and social

culture among the younger generations too. In Guatemala the phenomenon of the difficult generational change is not supported by investments to stimulate the younger generations to take over the family coffee business and adapt it to the changing context in a sustainable way. This is possible taking advantage of all the opportunities given by the developed specialty coffee market. Younger generations and businesses development are therefore the top priority targets of investment in Guatemala.
Finally, in India, it is recommendable to invest in helping the human and social capitals, particularly directing the investments to improving the hand labour availability, attracting it to the coffee estates. At the same time, it would be recommendable to invest into developing the physical assets, particularly into finding solutions for possible temporary hand labour shortages. It would also be positive to reduce the pressure over the financial assets by improving the market for specialty coffees in India.

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