Chapter

Non-Timber Forest Products as an Alternative to Reduce Income Uncertainty in Rural Households

Luz María Castro, Diana Encalada and Luis Rodrigo Saa

Abstract

Rural households face uncertain income due to several risks associated with markets, climate and productive uncertainties. In South Ecuador, subsistence seasonal agriculture constitutes the main livelihood strategy for local farmers. Non-timber forest products, such as *Caesalpinia spinosa* locally known as tara, constitute an alternative to diversify income. Tara is collected from natural areas, by mostly women, during male migration periods, which coincide with the dry season. To identify farmers´ income composition, a field survey was conducted among 125 farmers, who also happen to collect tara. Prevalent agricultural options for the region included maize, beans, cattle ranching, pigs and poultry. To calculate risk-efficient combinations, we applied Markowitz's portfolio theory, which combines options based on their income and risk performance. The results revealed that tara is only part of low-income portfolios, despite the low correlation between the markets. The exclusion in tara from high-income portfolios might be a consequence of its lower returns compared with other options such as maize and cattle ranching. Collectors need to improve efficiency during harvest and post-harvest processes to reduce loss, which is above 50%. If appropriately managed, tara could contribute to raising household income, alleviating agricultural risks and boosting gender equality.

Keywords: risk, income, diversification, NTFPs, sustainability

1. Introduction

Farming activities are often exposed to several sources of risk that are faced by households without enough information to support their management decisions. Production, marketing, financial, institutional and human risks are experienced by most farms, either independently or interrelated. Various socio-economic conditions affect people's livelihoods, such as the availability of employment opportunities, access to markets, agricultural development, the degree of linkages with urban areas and labour migration [1].

Several studies focused on the livelihood strategies in developing countries have highlighted the relevance of diversification to reduce risks [2]. Rural households diversify their livelihoods and combine various strategies to obtain food, goods and income. With increasing exposure to national and international markets, new opportunities are emerging. People at the forest fringe combine the exploitation of natural resources with farming, off-farm employment and labour migration [1]. The contribution of forest for income diversification is underrated though. Forests provide a wide range of goods and services to local dwellers that create opportunities to address many sustainable develop goals (SDGs). Sustainable forest management might promote economic growth and productive employment in rural communities, especially the poorer ones [3]. Moreover, the broad branch of non-timber forest products (NTFPs) can create greater inclusion of women in the field of sustainable forest management, boosting women empowerment [4].

Crop diversification and the inclusion of alternative options such as NTFPs can enhance the performance of low-income farms [5–7]. Over the past few decades, NTFPs have been playing a significant role in the improvement of livelihoods of communities around the world through cash income, food security, health care, nutrition, and other social and cultural ecosystem services [5, 8]. Besides the potential for income diversification, NTFPs have an important insurance role for farmers. In many developing countries, NTFPs are considered as a safety net that fills the gaps during emergencies and shortfalls in agricultural production [5]. In case of crop damage, the households harvest NTFPs for supplementary income [6].

Since the early 1990s, the role of NTFPs for sustainable forest use and poverty alleviation has received increased attention [1, 2]. Nevertheless, the income-generating capacity of NTFP extraction in natural forests is restricted to factors such as product availability, density and irregular distribution of valuable species. NTFP harvesting is mostly a part-time, seasonal and subsistence-oriented activity, complementary to farming [1].

According to the IPCC [9], climate change is expected to significantly impact the provision of NTFPs, especially in mountain regions. The increase in global average temperatures and change in precipitation patterns will impact the provision of NTFPs. Scientists foresee that warmer temperatures can drive to shifts in plant species distribution and richness, and some of them alert a rise in local extinction risks due to the competitive replacement of slow-growing plant species. Moreover, climate change is expected to increase exposure to other risks such as more frequent and severe forest fires, storms, landslides and floods [10]. Faced with this situation, it is necessary to implement long-term adaptation practices that guarantee the availability of NTFP and provide local communities with suitable livelihoods [11].

NTFPs have the potential to improve the livelihood of rural dwellers in tropical countries. In Ecuador, the market for NTFPs is rarely considered a profitable option because the accountability of harvesting and trade is deficient. *Caesalpinia spinosa* (Molina) Kuntze, locally known as tara, is a native species in the Andes [12]. Tara has been traditionally appreciated due to its multiple uses as firewood, construction material and fog catcher [13]. More recently, it has become a valuable NTFP alternative attributable to its high commercial value on growing international markets. Its pods and seeds are used for medicine, food and industry sectors based on their antimicrobial and antioxidant capacity [14–16]. The pods are used in the leather industry and for the manufacture of dyes because of their high content of high-quality tannins. In addition, the seeds are rich in a hydrocolloid called tara gum highly appreciated for the manufacture of food thickeners, cosmetics, varnishes, paints, etc. [17, 18].

In southern Ecuador, tara is distributed in wild populations along with dry tropical mountain forests, which is one of the most threatened forests in the world [18, 19]. This area is also affected by poverty, around 29% of the population is regarded as poor according to the National Institute of Statistics [20]. In this region, tara is mainly collected by local women [21]. Females are more likely to be engaged in NTFP collection [8]. Thus, policymaking and land-use planning must consider that NTFPs are part of the overall livelihood strategy of the people involved [6].

In order to understand the livelihood strategies of poor households in dry forest areas and their interactions with NTFP, as a source of supplementary income, this research was conducted in southern Ecuador. Throughout this study, we aimed to determine the current composition of farmers´ income. We also analysed the share of the tara on overall farmers´ income and the harvesting strategies. Finally, we assessed the risk related to the main farmer's activities in the region and how NTFPs can be incorporated as part of diversification strategies to cope with farming risks.

2. Risk and risk management in agriculture

Landowners make decisions every day concerning farming operations that affect their income. Several factors may affect the performance of the activities, some of them are deterministic while others are rather stochastic [22]. Many of the factors that affect farmers´ decisions cannot be predicted such as weather conditions, market price volatility, labour availability, machinery, equipment failure and government policy change. The most common sources of risk in farming can be divided into five areas (**Figure 1**) [23].

Farming has become increasingly riskier over the years, due to market liberalization and globalization. This situation affects smallholder farmers severely, they need to improve skills for both production and business management. Changes in prices are beyond the control of any individual farmer. Price movements follow supply and demand trends, which change unexpectedly affecting the market price [24].

Financial risk occurs when money is borrowed to finance farm businesses [23]. Risks are associated with future interest rates, lender's willingness to provide funds and the ability of the farmer accomplish loan repayment. Smallholder farmers who borrow money at high-interest rates are prone to fail debt repayments, especially in

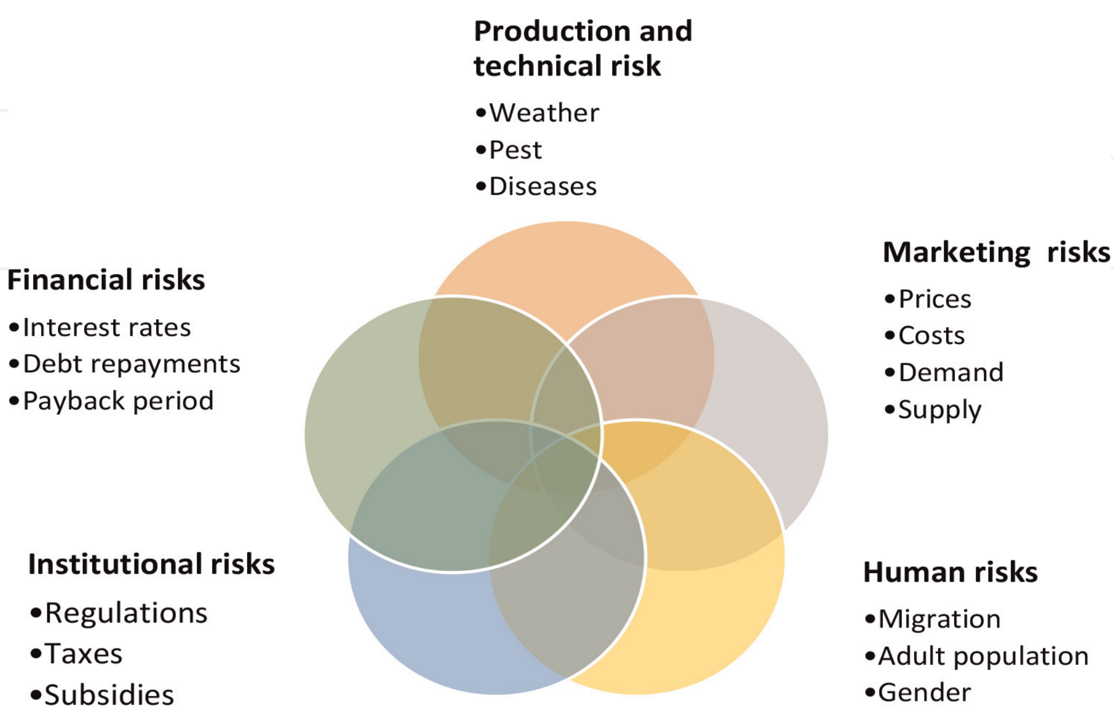

Figure 1.
Sources of risk in farming.

situations of lower than expected prices, combined with low yields, which can even lead to the sale of the farm. Another important source of risk comes from government policy affecting farming, such as price support and subsidies. Subsidies and regulations are examples of decisions taken by the government that can have a major impact on the farm business [24]. Finally, it is important to mention human-related risks because, in many regions, labour migration from rural areas is a common factor. Migration can cause labour shortages, farmers often face uncertainty concerning labour availability to meet demand during a farming season.

Risk management involves anticipating potential problems and planning to reduce their detrimental effects [23]. There are several strategies that farmers apply in order to cope with risks related to land use. Farmers can reduce risk by applying new technologies and practices designed to address specific risks, common to their area of production. Risk-reducing inputs (e.g. fertilizers and integrated pest management) might reduce the risk of low yields and crop damage. Similarly, irrigation reduces the risk of low rainfall. New seed varieties are being developed with certain characteristics to be resistant to drought, disease and pests. Nevertheless, not all inputs might reduce risk, even if fertilizer is used, the crop still depends on water availability, which may or may not be favourable. When soil moisture levels are low, using a fertilizer can still result in low yields. Understanding how farmers make land management decisions is critical to designing strategies to reduce risk exposure. Profitability of a particular land use obviously encourages farmers to allocate land to it; nevertheless, motivations behind decisions are often more complex than simple profit maximization [25].

2.1 Land-use diversification

Farmers' decisions about how best to use resources are driven by the goal of improving their well-being. Well-being is defined across many dimensions, including income, security of livelihood and health. Decisions about land use are influenced by the potential benefit of each activity, which, in turn, depends on the available technology, market and environmental conditions [26].

A key factor to consider is farmers' preferences towards risks. People generally do not become involved in risky situations unless there is a chance of making high profits. Many farmers around the world integrate crops and livestock to reduce risk and improve efficiency and sustainability. The risk involved with the farming options can be an essential factor in assessing preferences, because risk-averse farmers tend to choose the option with the lowest uncertainty, despite the fact that the potential reward may be lower as well [22]. Farmers are often regarded as risk-aversive, which means they give up on profits provided that a certain income is guaranteed.

For risk-averse farmers, land-use diversification improves the overall performance of the farm because it spreads risk among several crops, which should have a low market correlation [27]. Risk-averse farmers may achieve high levels of risk reduction by mixing two or more land-use options whose financial yields fluctuate independently from one another (low or negative correlations). In other words, in periods when returns from one asset drop, another one may generate unexpectedly high returns, thus moderating the effects of economic booms and busts [25].

2.2 The safety-net use of non-timber forest products

Evidence suggests the potential of NTFP to contribute to conservation of forest and to improve livelihood of rural landowners. Nevertheless, the exploitation of NTFP has often been neglected both in policy and research, because they are often regarded as secondary forest products. Recent research suggests that NTFPs are an important source of cash income for communities living in remote areas and safety net for diversifying income along the year [6]. Rural households, which have limited credit and insurance options, apply diversification strategies in order to reduce aggregate risk. The safety-net use of NTFP extraction may take the diversification strategy equivalent to a portfolio analysis, because the households use NTFP extraction as a risk-free asset [28]. Even though NTFP extraction might have a low annual value, it can provide insurance in the case of unexpected losses.

NTFP extraction appears to be efficient for poor rural households. Many NTFPs do not have strong positive correlation among themselves or with agricultural output [7] so they can be efficient risk-management instruments. Two characteristics of NTFP are important to note. First, there are low capital and skills requirements to NTFP extraction as well as open or semi-open access to the resource, so poor households can easily extract the resource. The poorest people are those who are the most engaged in NTFP extraction. Second, NTFPs habitually have low return to labour, so they have poor potential to alleviate poverty [28, 29].

3. Methods

The study area is located in mountain dry forest areas in southern Ecuador, where tara populations naturally occur, and the population is currently participating in the market of tara (see **Figure 2**), covering an approximate extension of 2396 km^2. The area is characterized by a temperate and dry climate, with two well-defined seasons: dry and rainy, the latter from December to April. The average altitude is 1385 metres above sea level. The annual rainfall has a mean value of 953 mm, and the annual temperature mean value is 18°C.

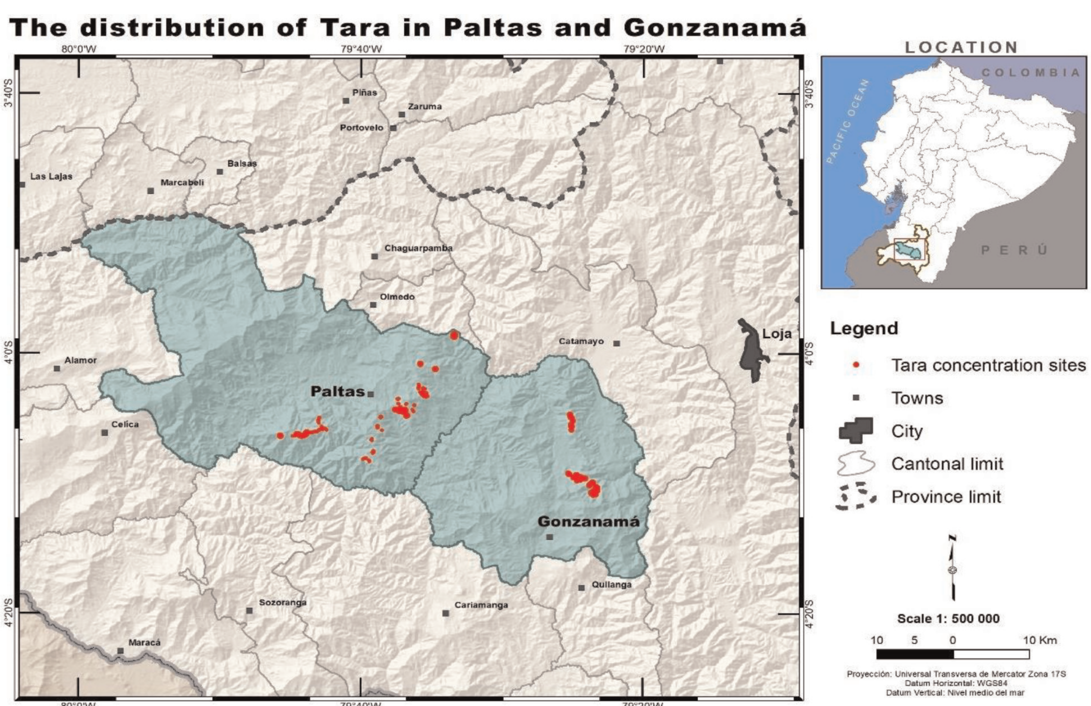

Figure 2.
Location of the project.

The estimated population in 2020 was about 34,424 people, with approximately 8200 households. More than 70% of the population live in the countryside, scattered across numerous small villages and communities. This region is characterized by subsistence agriculture and livestock production, with a poverty rate of 29%. It is estimated that 30% of households live below the country's poverty line [20].

3.1 Data collection

This study is based on primary data collection through a field survey to 125 rural households between January and July 2019. The questionnaire was focused on the socio-economic characteristics of the households, the assets and the main sources of income. Other questions include the participation of the different members of the household in the different income-generating activities, such as agriculture, livestock and the collection and sale of NTFPs.

Data were analysed both qualitatively and quantitatively to provide a deeper understanding of household production, management and use of NTFPS. The quantitative data were analysed using the Statistical Package for Social Science (SPSS) software and Microsoft Excel to obtain descriptive statistics such as percentages of responses, frequencies, means and standard deviations.

To calculate family income, volumes of production were multiplied by the current price at farm gate. Net household income was calculated as the difference between household income and production cost, main costs included labour and inputs (e.g. fertilizers, manure, seeds and pesticides).

3.2 Risks assessment and diversification

In order to assess risk, information on prices of the most valuable agricultural options for the study area was collected from Faostat for the period 1999–2009 [30]. As information of price for tara for the Ecuadorian market is scarce, we used data obtained from Peruvian institutions as a proxy, since the market for tara is better developed there.

Price values were simulated in an excel sheet based on their mean value and standard deviation using Eq. (1). This simulation generated normal random variables for price for each year of time horizon.

$$\mathrm{Y} = \mathrm{NORMINV}\left(\mathrm{RAND}(), \overline{P}, \mathrm{STDP}\right) \tag{1}$$

where Y is normally distributed random variable, NORMINV is excel-based assumed normal distribution, RAND () is the probability, P is average of price, and STDP stands for its standard deviation. We later performed a Monte Carlo Simulation to model the probability distribution of returns. Based on this information, we analysed the level of dependency of the markets through correlation and covariance analysis.

Diversification was performed through the application of the portfolio analysis [22]. Our work model farmers' options for balancing economic return and risk. This approach attempts, by means of the allocation of land to various land-use practices, to maximize the expected economic return, for a given level of accepted risk, which is represented by the standard deviation (SD) of economic return, through careful selection of the proportions of agricultural options. Those portfolios that provide the largest economic return for a given SD are termed efficient portfolios. All others are considered inefficient.

The expected economic return of a portfolio with two or more assets, Rp, is obtained by adding the expected economic returns, ri, weighted by their proportions, fi, of the single land-use options.

$$R_p = \sum_i f_i \cdot r_i \tag{2}$$

The SD of economic returns for the portfolio, σp, is quantified as follows:

$$\sigma_p = \sqrt{\sum_i \sum_j f_i \cdot f_j \cdot \text{cov}_{i,j}} \tag{3}$$

with:

$$\sum_i f_i = 1 \quad f_{i,j} \geq 0 \quad \text{var}_i \coloneqq \text{cov}_{i,i} \quad \text{cov}_{i,j} = \rho_{i,j} \cdot s_i \cdot s_j$$

where i and j are the indices for the specific land-use options; fi is the proportion of a specific agricultural land-use practice in the portfolio; si is the SD of returns for land-use practice i; ρi,j is the coefficient of correlation between the returns for options i and j; vari is the variance and covi,j is the covariance between the economic returns for options i and j. Using this method, the effects of diversification can be identified for different combinations of land-use options, provided that the variability of their financial return is not perfectly positively correlated ($\rho \neq 1$).

The selection of the optimal portfolio can be made based on the reward-to-variability ratio (Eq. (4)) [31], where the portfolio return, Rp, minus the return of a riskless benchmark investment, Rri, is divided by the portfolio standard deviation σp.

$$\max R_p = \frac{\text{Rp} - R_{ri}}{\sigma_p} \tag{4}$$

The riskless benchmark yield, Rri, is assumed as the interest yield that famers could obtain when investing in a safe financial asset. We assume that farmers can sell their land and invest that money in the capital market at an interest equal to 5%. Value of land has been set at a conservative value of US$2000 per ha, for which a riskless yield equal to US$100 can be obtained yearly.

4. Results and discussion

4.1 Livelihood strategies

Subsistence farming is the main economic activity in the region. Rain-fed subsistence farming relies on traditional crops such as corn and beans. Other representative crops are peas, coffee and peanuts on a smaller scale. Only 25% of the land is used for productive activities, due to the low soil quality and lack of labour, irrigation and financial resources. Regarding livestock production, landowners are engaged with cattle, pig and poultry production (**Table 1**). We observed high variation among the returns of households along with all the activities.

Concerning the two main farming options, a meaningful number of households depend on family labour (**Table 2**), nevertheless, hired labour is also required, especially during seasonal migration periods from June to December. Improved seeds are seldom used so far in the region, as most households admit to using their seeds. Technification of farming is also low, fertilizers either organic or conventional are occasionally used at the farms, the use of pesticides is more habitual though. The number of households that are reported to have loans and debt is also limited, most of them work with local banks and financial cooperatives.

4.2 Income from tara and other NTFPs

The data revealed that about 21% of the people collect fuel wood (e.g. *Eucalyptus globulus* and *Acacia macracantha*). An even smaller proportion collect NTFP other than tara, mainly *Marsdenia condurango* Rchb.f., locally known as condurango. The total amount of condurango harvested is later sold at the local market. There is an increasing demand for the product, but the collection occurs over a brief period, mostly by women. Tara, on the other hand, has a more established local market (**Table 3**). It is collected once a year in natural forests, mainly public areas. The

		Annual income per household		
Product	**Number of households**	**Mean USD**	**Max USD**	**Min USD**
Maize	107	670	9300	16
Beans	102	456	3445	24
Cattle	27	2181	15577	312
Poultry	92	282	1585	54
Pigs	37	550	2944	134

Table 1.
Annual returns of the main products in the study area.

	Number of households	
	Maize	**Beans**
Family labor force	57	37
Hired labor	64	35
Improved seeds	23	5
Organic fertilizers	20	10
Conventional fertilizers	27	15
Pesticides	60	37
Machinery	71	27
Credits and debt	22	14

Table 2.
Forms of production.

	Number of households	Total amount harvested (ton)	Total amount sold (ton)	Production (ton)			Income (USD)		
				Mean	max	min	Mean	max	min
Condurango	10	0.58	0.58	0.058	0.091	0.011	105	270	7.5
Tara	118	58.5	26.3	0.2	2.0	0.040	100	900	11

Table 3.
Local NTFPs harvested in the study area.

collection period ranges from May to December. Nevertheless, there is a waste of around half of the harvest caused by inadequate storage which produces losses due to fungus, under moist warm conditions. Training programmes and simple equipment can boost production, speed up processing times and reduce losses, they are essential tools for local farmers to enhance harvesting and post-harvesting.

In recent years, research on the role of forest-related income in rural livelihoods has been gaining momentum. Case studies around the world study the interactions between forests and livelihoods, and the contribution of NTFPs range from 6 to 45% [32]. In the case of tara, it currently represents less than 5% of household income. This activity generates an annual average of USD 100, which complements the income from agriculture. The potential of NTFP to improve farmers´ livelihoods should not be exaggerated as poorer communities are the main actors in NTFP extraction [6].

4.3 Risk assessment and diversification

Farmers often choose productive activities that maximize their well-being, given the resources and opportunities available to them. To assess the risk involved in farming activities, five productive options were selected: maize, beans, cattle ranching, pig and poultry together with tara. **Figure 3** displays the prices of the selected products over the period 1999–2019.

Based on this information, we calculated the correlation matrix to observe the degree of dependency between the selected options. We observe a considerable dependency among the markets of beans and animal breeding as shown in the correlation matrix (**Table 4**). Tara on the other hand has a medium positive correlation

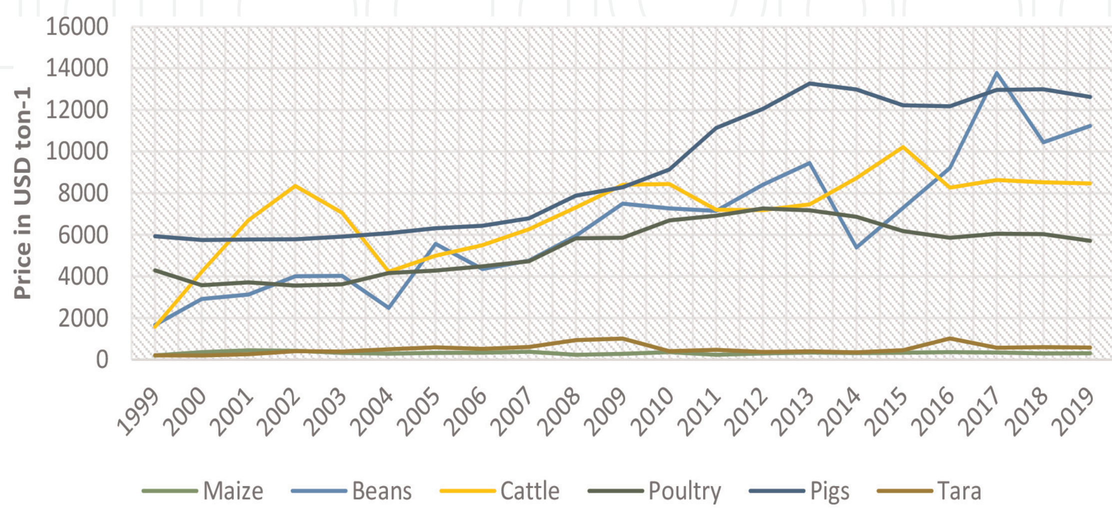

Figure 3.
Price volatility of farming options.

	Maize	Beans	Cattle	Poultry	Pigs	Tara
Maize	1	–0.043	0.292	–0.330	–0.155	–0.185
Beans	–0.043	1	0.668	0.687	0.844	0.409
Cattle	0.292	0.668	1	0.561	0.661	0.362
Poultry	–0.330	0.687	0.561	1	0.863	0.240
Pigs	–0.155	0.844	0.661	0.863	1	0.197
Tara	–0.185	0.409	0.362	0.240	0.197	1

Table 4.
Correlation matrix.

with all the agricultural options, except maize. NTFP collection is positively correlated with an agricultural shortfall and expected risk [33].

To achieve income diversification, combinations of five agricultural products and tara were tested by applying the portfolio theory. We calculated portfolios for given amounts of return subject to a minimum standard deviation, as a measure of risk. The resulting shares were highly dependent on the performance of each asset in terms of return and risks. Tara, for instance, was part of the portfolios with the lowest returns (**Figure 4**). It only was part of the portfolios with returns below 300 USD. As the amount of portfolio income rises, the share of tara drops to zero. This situation is a result of the low returns that tara harvesting delivers so far. Nevertheless, improved management of the species might enhance the overall financial performance of tara as an income generator option for rural households. So far, we have measured the risk of tara based on the volatility of the price, but little is known about how natural risks affect the supply of pods.

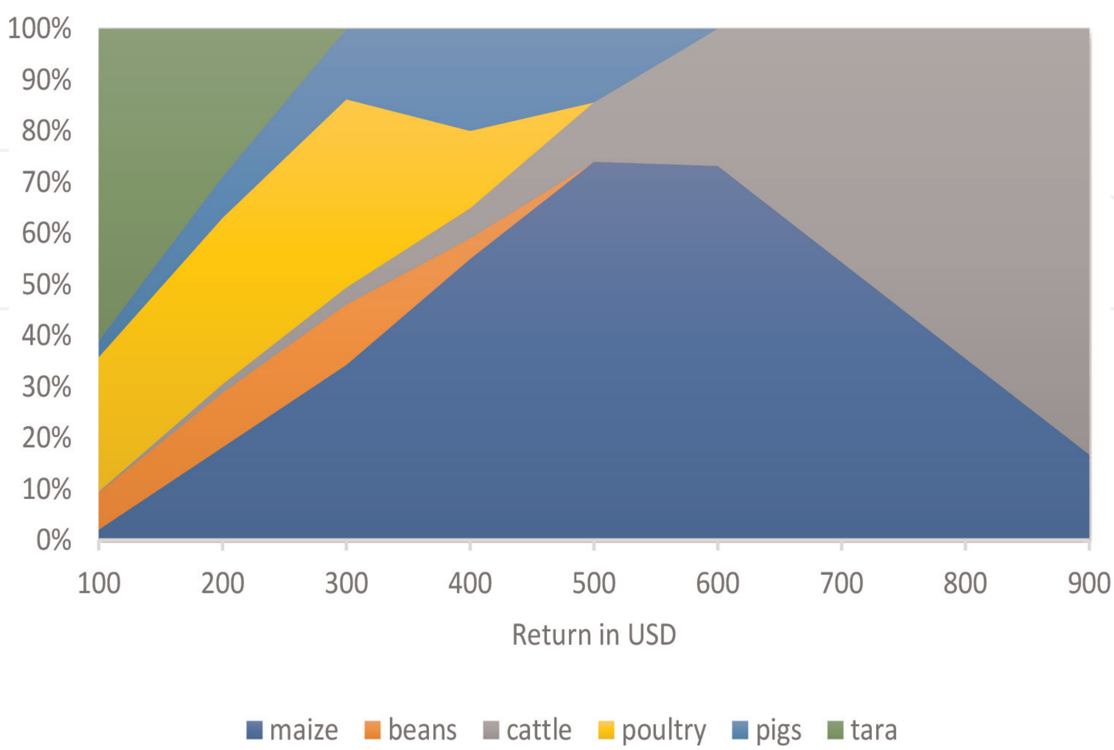

Figure 4.
Share of agricultural options in optimized land-use portfolios based on expected return.

		Portfolio Share %						
Return USD	**Sd USD**	**Maize**	**Beans**	**Cattle**	**Poultry**	**Pigs**	**Tara**	**Sharpe ratio**
100	32.24	0.02	0.07	0.00	0.26	0.03	0.61	0.620
200	37.77	0.18	0.11	0.02	0.33	0.08	0.29	3.178
300	58.43	0.34	0.12	0.03	0.37	0.14	0.00	3.765
400	86.89	0.55	0.04	0.06	0.15	0.20	0.00	3.683
500	122.86	0.74	0.00	0.12	0.00	0.14	0.00	3.418
600	190.53	0.73	0.00	0.27	0.00	0.00	0.00	2.729
700	286.94	0.54	0.00	0.46	0.00	0.00	0.00	2.161
800	393.37	0.36	0.00	0.64	0.00	0.00	0.00	1.830
900	503.52	0.17	0.00	0.83	0.00	0.00	0.00	1.629

Table 5.
Land-use portfolios for southern Ecuador.

Land-use portfolios were more diverse under 500 USD, above that income, portfolios were dominated by maize and cattle ranching. This behaviour is explained due to two main reasons, the financial performance of options and safety-net effects. First, cattle ranching delivers higher profits than any other option, despite the risk involved with the activity. Cattle also serve as a saving strategy used by farmers under distress. Maize, on the other hand, has a low risk compared with the other options and serves food security. Farmers who operate under subsistence conditions tend to be the most risk-averse. The provision of food for their dependants is an overriding priority for many of them. Activities with a monetary reward are frequently forgone in favour of meeting the objective of producing their own food.

We determined the optimal land-use portfolio by applying the Sharpe ratio, which is constructed based on the performance of the reward-to-variability ratio (**Table 5**). According to this method, the portfolio with the best performance was the one that achieved 300 USD. Above this bar all the portfolios deliver a riskier outcome, they are thus, inefficient.

5. Discussion and conclusion

Rural households relying upon subsistence agriculture face multiple uncertainties that so far are poorly understood. Moreover, they usually have poorer risk management strategies due to lack of training, limited access to credits and long distance to local and regional markets. This study, based on rain-fed subsistence agriculture, explores income diversification based on farm options and NTFPs, as a strategy to cope with risks.

Even though a body of literature has documented the potential of NTFPs' on poverty reduction [1, 5] livelihoods improvement and environmental sustainability [34], evidence suggests that the impact that NTFPs might have on household income should not be overestimated [6]. This is particularly important because landowners engaged in the collection of NTFPs generally live in poor conditions where even the most basic healthcare and educational services are lacking [35].

Even though the collection of tara is a commercial activity with potential for the economy of the study area and a source of income for women, we observed that its extraction has low poverty alleviation effects, due to its low return. Nonetheless, it can become a viable tool to compensate for the agricultural risk, if properly managed during harvest and post-harvest campaigns to reduce losses. The assimilation of tara as a viable business among farmers can boost the achievement of SDGs related to economic growth, decent work and gender equality [3, 4, 21].

Tara is being harvested from wild populations, a common pattern by poorer rural households in developing countries. As generally, harvest leaves the forest structure intact, it can also be promoted as an alternative for forest conservation. Sustainable commercial exploitation of NTFP could serve as a stimulus to sound forest management [13].

NTFPs are among the forest products that better serve as livelihood resources in the face of climate stresses [36], since NTFPs can provide income opportunities [37]. The use of NTFPs has also been recognized as important for the climate resilience of small production systems since natural forests are more resistant to climate change than monocultures [38, 39]. Migration is one adaptation strategy practised by farmers due to climate change as it provides off-farm income [40]. Nonetheless, we observed in the study area that it affects household performance because it reduces labour availability during the cropping season.

NTFP trade also face risks and challenges, which can lead to only short-term returns, rather than sustainable businesses [41]. They recommend to paying attention to the governance of resources, organizations and gender. All of these factors are extremely relevant for most developing countries, and certainly for our case study because collectors of tara are mostly women. The authors recommend considering on how men and women participate in the collection, who benefits and controls NTFP harvest and trade and how the benefits are shared within the household. Lack of knowledge can also affect the performance of NTFP, we found a waste of about half of the harvest due to fungus. Limited knowledge about storing technologies, processing opportunities, market information and how to domesticate NTFPs constrains its overall outcome as a generator of income.

Moreover, the contribution of NTFPs to improved livelihoods can be assured through a process of gradual domestication in man-made vegetation types such as forest gardens and plantations. There is often a gradual transition from the collection of wild products in natural forests to enrichment planting in secondary forests and managed home gardens. Tara is tolerated in the farms, where it provides shade and serves as a reference in the division of farms [13]. Future studies should assess the potential of tara as a commercial plantation to reduce the impact on wild areas and reduce the time spent by farmers for collection, as natural areas are located remotely.

Acknowledgements

The authors express their gratitude to Nature and Culture International for the financial support during this research and to Stefany Loayza, who collaborated during the field survey.

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