Ecological and socio-economic aspects of hair sheep keeping in the tropical rainforest of Ecuador

Brief report of the GTZ-TOEB project No 90.2136.1-03.100

written by

CORNELIA CLAUS, JÜRGEN FISCHER, ALEJANDRO HERRERA & GEROLD RAHMANN

1 Introduction

With the start of oil exploitation in Sucumbíos and the construction of roads in the Seventies, poor people from the highlands of Ecuador moved into the tropical rainforest to find jobs and to start farming. On the settlements of an average size of 50 hectare per farm, the primary rainforest was cut to establish cash crop production like coffee and cocoa and to keep cattle on artificial pastures (ROEDER 1994). Not adapted land use led to devastation of large areas, mainly due to cattle keeping. Since 1991, the German Agency for Technical Cooperation (GTZ) has tried to develop more sustainable land use systems in the region (PROFORS). The introduction of hair sheep into the agro-silvo-pastoral systems was part of this approach. In an interdisciplinary research project - funded by the GTZ (Tropical-Ecological Complementary Programme; TÖB) - the ecological and socio-economic impact of hair sheep was evaluated. The comparison to cattle keeping was the major theme in the survey.

2 Methods

The research was carried out from November 1996 to May 1998 on small scale farms in the region of Sucumbíos in Ecuador (Figure 1). From approximately 130 farms with hair sheep, 25 farms were chosen for a detailed survey. These farms had approximately about 320 hair sheep and 160 cattle (meat and milk). The chosen farms were classified into four different farming systems (FS):

- FS 1: separate grazing of hair sheep and cattle on artificial pastures (silvo-pastoral).
- FS 2: free range grazing of hair sheep on artificial pastures, mixed grazing with cattle (silvo-pastoral).
- FS 3: hair sheep grazing in coffee and cocoa plantations (agro-silvo-pastoral).
- FS 4: mixture between farming system 2 and 3 (agro-silvo-pastoral).

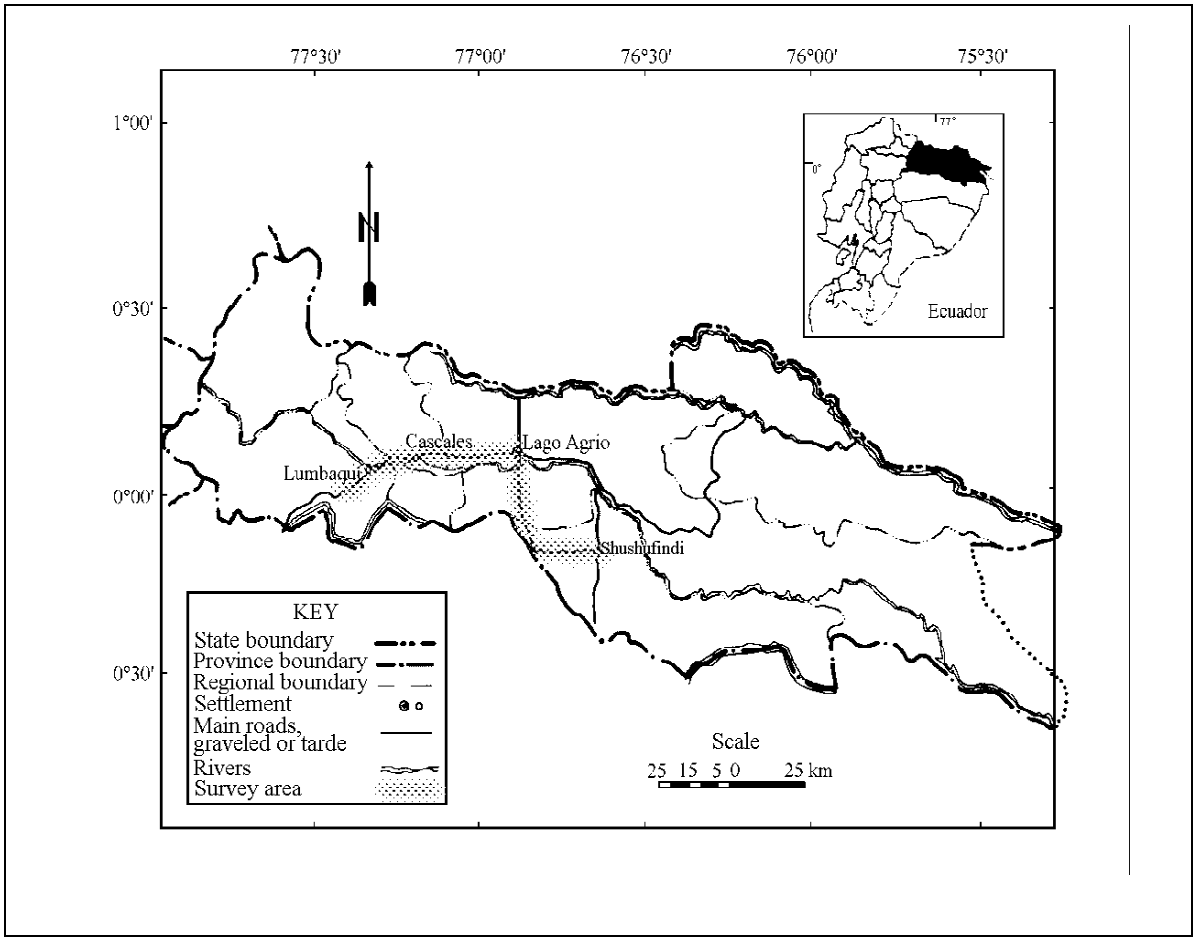


Figure 1: Map of Sucumbíos/Ecuador (PROFORS 1993, changed)

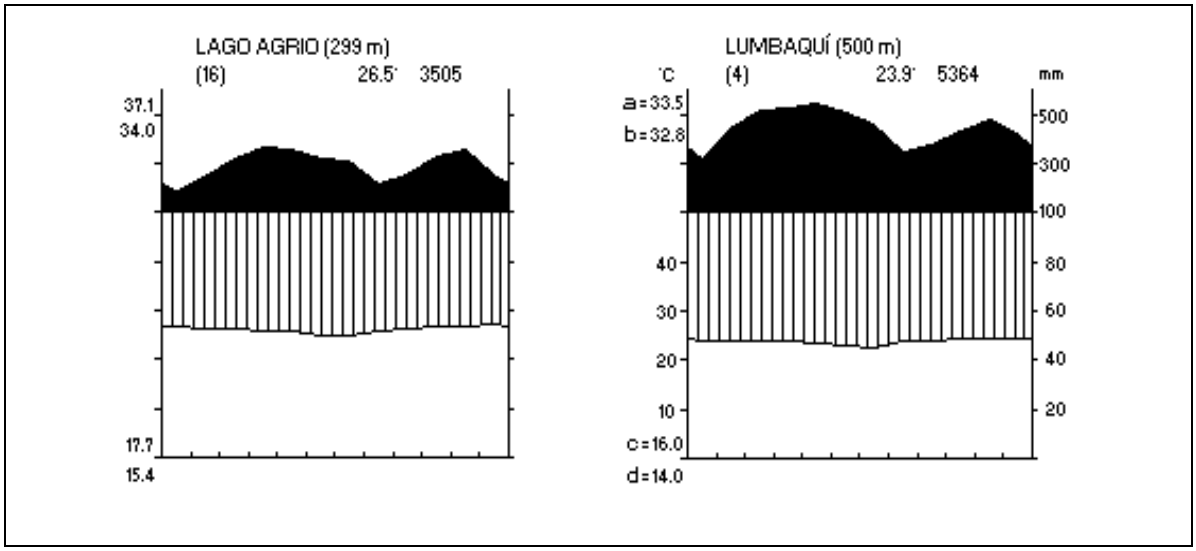
The chosen farms were visited regularly by scientists to collect data on ecology, animal husbandry and socio-economics. For socio-economic questions, the techniques of Rapid Rural Appraisal (RRA) were used. The livestock keeping on the farms was analysed as far as animal health, reproduction, productivity and profitability were concerned. The carrying capacities of plantations and artificial pastures and the fodder value of the vegetation was assessed and the climatic and edaphic conditions evaluated. Vegetation sampling and measurements on the influence of animal grazing on the pastures took place.

3 Frame conditions in the survey region

3.1 Ecological frame conditions

The most important frame condition is the climate. It determines the hydrology, the vegetation and the soil. The climate in the survey region is perhumid as typical for tropical rainforests (Figure 2). Each month has rainfall of more than 100 mm. The highest rainfall is in May (365 mm) and the lowest in January (192 mm). The annual rainfall is between 3,500 mm in Lago Agrio

(300 m asl) and 5,400 mm in Lumbaqui (500 m asl). The average temperature is between 26.5 °C in Lago Agrio and 23.9 °C in Lumbaqui.



Data source for Lago Agrio: Dirección General de Aviación Civil 1997; for Lumbaquí: Mano Verde 1990; a: absolute maximum (highest measured temperature); b: average daily maximum of the warmest month; c: average daily minimum of the coldest months; d: absolute minimum (lowest measured temperature). (compare WALTER & LIETH 1960)

Figure 2: Climate of Sucumbíos

The rainforest is the natural vegetation but it has been cut to establish cash crop production and artificial pastures. The soils of such farm land is classified as Inceptisols (US soil taxonomy) (SCHWINN 1987, PROFORS 1993). This means that they are relatively young and fertile, compared to the soils in the deep rainforest in the Amazonas basin.

3.2 Land use and animal husbandry

Immense migration of poor and often landless people was seen after the establishment of roads into the research area of Sucumbíos, due to oil exploitation. Beside the roads (first line) the people started to cut the virgin rainforest illegally to establish farm land: "man without land moved to land without man". After the first line of settlement along side the roads was occupied, the second line was created, two kilometres away. Currently, the 8th line is being used for new farm settlements, 16 km away from the roads. To get registration on the farm land, permanent cultivation was required, the average farm size was about 50 hectares (250 m x 2,000 m). In 1990, only 51% of the farms had a legalized private property registration. Currently, typical farm land has 40% artificial pasture, 9% cash crops (mainly coffee and cocoa) and 42% remains primary and secondary rainforest. The farms represent "low input - low output" systems. The farms´ work is mostly done

by family labour, only in high seasons are casual workers employed (particularly in coffee bean harvesting). Animal husbandry has a high status for the farmers. Both men and women work in livestock farming. Females work more in dairy and small stock, men more on land preparation/maintenance and in beef cattle.

Hair sheep keeping has taken well on the farms but the status is lower than for cattle. The meat is consumed and is well appreciated. Therefore, hair sheep are recognized as complementary livestock to cattle but not as a substitute.

With the establishment of artificial pasture, cattle keeping started in the early Seventies in the region. The pastures are fenced and rotational grazing of cattle is usual. Nowadays, there are about 42,000 cattle in Sucumbíos. 1990, 56% of the cattle were dairy cows and 44% for beef production. The milk yield is low and mainly for subsistence purposes, beef production is for selling. The keeping conditions of cattle are fair.

In 1990, 100 hair ewes were introduced into the region by PROFORS. Presently, about 120 to 140 farmers keep approximately 1,000 ewes, mainly in the first and second line beside the roads. Controlled breeding is not practised. Due to imports, there are still 80% of the hair sheep pure-breeds. Barbados Blackbelly (local: Barriga Negra) and Pelibuey-West African (local: Sudan) have 40 % each and 20% are crossbreeds. The sheep are used for lamb and mutton production, mainly for subsistence. Free range grazing is the most practised form of keeping, the labour input minimized. A recently funded hair sheep association (ACOAS) is trying to train farmers in animal health, nutrition and keeping.

4 Results

4.1 Pasture productivity and carrying capacity

Brachiaria decumbens is the most used grass for seeding on artificial pastures. The productivity is 6.5 to 11 tons dry matter (DM) per hectare and year, depending on soil fertility, livestock rotation, defoliation rate and spittlebug (*Mahanarva sp., Zulia sp*.) damage (VALERIO et al. 1996, FISHER & KERRIDGE 1996). The usual mean stocking densities of *Brachiaria decumbens*-pastures with rotational grazing is 0.6 Livestock Units (1 LU= 400 kg liveweight) cattle per hectare and year. When mixed grazing, 0.5 LU ha^{-1} a^{-1} sheep continuously graze in addition to cattle, thus reaching a better fodder utilisation. *Brachiaria decumbens*-pastures with only sheep grazing have a mean stocking density of 0.9 ha^{-1} a^{-1}. *Brachiaria decumbens*-pastures in Sucumbíos are nowadays undergrazed. In a sheep grazing experiment with short grazing cycles of four weeks (grazing rest of three weeks) a pasture yield of 11 tons DM ha^{-1} a^{-1} and 8 kg grain maize per 0,15 LU (1 adult sheep à 35 kg liveweight) and year, a mean stocking density of 3,6 LU ha^{-1} a^{-1} could

be achieved. In such systems a liveweight gain of 400 kg ha^{-1} a^{-1} is possible. *Brachiaria decumbens* shows a good fodder value (crude protein content of 14 %) for sheep after three weeks grazing rest. This decreases while grazing rests prolong.

On a *Brachiaria decumbens* pasture with a yield of 6.5 ton DM ha^{-1} a^{-1}, rotational grazing (typical grazing cycle for cattle in the region with six weeks of grazing rest) a mean stocking density of 1.8 LU ha^{-1} a^{-1} without additional concentrate feeding was achieved. Liveweight gain was 321 kg ha^{-1} a^{-1}. To compare the mean stocking densities of sheep and cattle, densities were corrected assuming that both pastures had the same yield and that the sheep did not have additional concentrate fodder. The mean stocking densities in Sucumbíos are shown in Table 1.

The grass cover under agro-silvo-pastoral systems (mostly coffee) is spontaneous and has a yield of 1 to 2.8 tons DM ha^{-1} a^{-1}. Usually cattle is not kept on coffee plantations, due to possible damage on the roots by trampling; that is not the case with sheep. From 34 classified spontaneous plant species, 14 are not eaten by sheep. Between 2 % (*Panicum polygonatum*-vegetationtyp) and 81 % (*Axonopus compressus*-vegetationtyp) of the biomass is grazed by sheep. The spontaneous cover sites are continuously grazed by sheep with a mean stocking density of 0.5 LU ha^{-1} a^{-1} and 40 kg liveweight gain ha^{-1} a^{-1} can be assumed.

Sheep browse some invading shrubs like *Vernonia spp*. (local: Chilca) and regrowth of *Psidium guajava* (local: Guayava). Under coffee and cocoa, this is an advantage to reduce clearance efforts. A problem can be the bark stripping on coffee and citrus trees. This happens when other fodder is scarce.

Table 1: Mean stocking rates (LU ha^{-1} a^{-1}) of pasture sites in Sucumbíos.

pasture site	continuos grazing		rotational grazing		Sum
	LU cattle	LU sheep	LU cattle	LU sheep	LU
Brachiaria decumbens	-	0.9	-	-	0.9
	-	-	-	(2.7)[1]	2.7
	-	-	0.6 (2.4)[1]	-	0.6 (2.4)
	-	0.5 (0.7)[2]	0.6 (0.8)[2]	-	1.1 (1.5)
permanent crop with spontaneous cover	-	0.5	-	-	0.5
			(0.8)[1]	-	(0.8)

Note: [1]Determined on grazing experiments. [2]Estimated on grazing experiments and experience values in Sucumbíos. The numbers outside the brackets refer to the typical

mean stocking densities in Sucumbíos, the one inside stand for possible mean stocking densities.

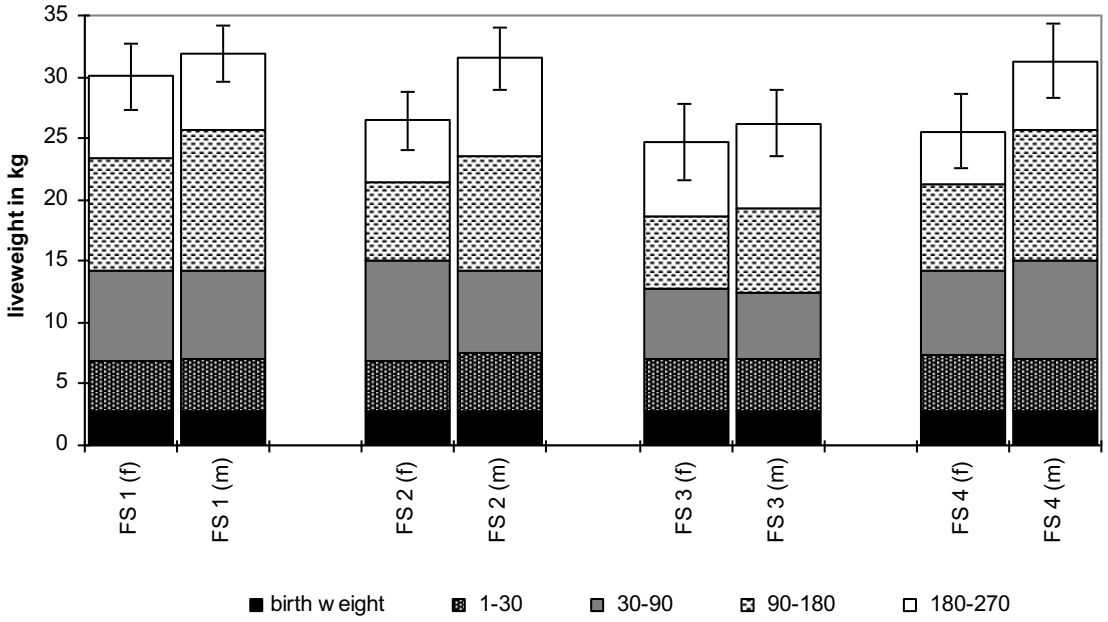
4.2 Livestock productivity and reproduction

Both cattle and sheep are adaptable to perhumid conditions as in Sucumbíos. Problems occur when livestock management is bad. Infections and diarrhoea are the major problems in livestock keeping. Additionally, there are accidents and deaths by dogs or pigs. Hoof-rot of hair sheep is a serious problem in these wet locations. These problems are mainly valid for sheep keeping. Particularly new born and/or weak lambs suffer through inadequate management. Therefore, 50% lamb mortality is possible but on the farms of the survey a lamb mortality rate of 22% and calf mortality rate of 14% was observed (Table 2). The mortality rates for adult stock are low. This is acceptable for the local conditions. The breed Barbados Blackbelly has higher mortality rates than Pelibuey-West African breeds.

Table 2: Mortality rates (%) on the farms of the survey 1997

	hair sheep	cattle
young stock	22	14
adults	3	2

Rabies is present in the region (bats are the vectors) but other pests like rinderpest, tuberculosis, brucelosis or others could not be evaluated. A difficult ecto-parasite is *Dermatobia hominis* (local: tupe). For rabies and tupe, cattle are more affected than sheep. Babesiosis and anaplasmosis have not been found but trypanosomiasis in in blood samples of sheep and cattle. The infected animals did not show sickness due to these blood parasites. A wide range of different endo-parasites could be found. The farmers treat cattle regularly but not sheep. Veterinary services are rarely available, only occasionally used for cattle (mainly dairy cattle) and have not been considered in hair sheep keeping.



remarks: f = female; m = male; FS 1 and FS 2 silvo-pastoral (artificial pastures), FS 3 and 4: agro-silvo-pastoral (in coffee plantation)

Figure 3: Liveweight gain of lambs for different farming systems

Both sheep breeds are not seasonal. The lambing rate is 1.4 born lambs per birth, the fertility rate is 1.4 born lambs per ewe and the total productivity rate is two weaned lambs per ewe and year. This is acceptable for the local conditions. 62% of the births were single lambs and 33% were twins. The breed Barbados Blackbelly has more twins and triplets than the Pelibuey-West African hair sheep. The average birth weight is 2.7 kg and the average lambing interval is 214 days. The daily weight gain of the lambs is about 100 g d^{-1} between birth and 270 days. This is a good result. The weight gain on artificial pasture is much better than under coffee and cocoa with local vegetation.

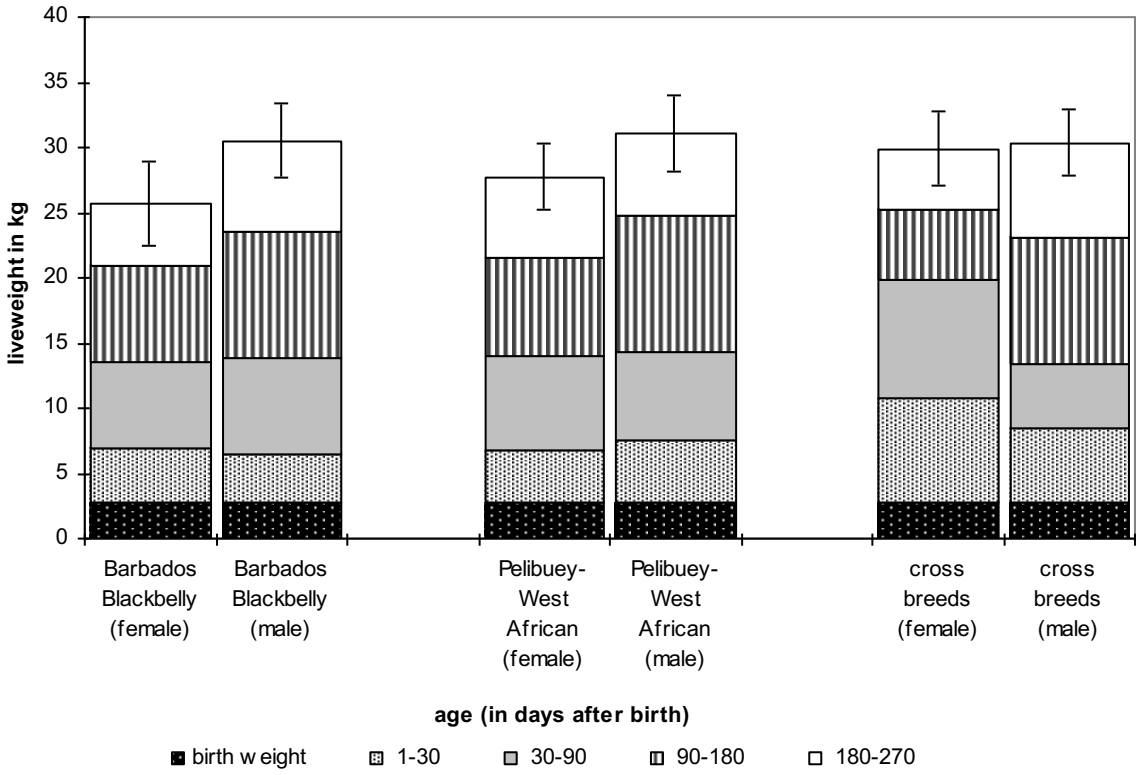


Figure 4: Liveweight gain of lambs for different breeds

Cattle have an average calving interval of 15 months, the first birth is at 28.5 months. In 1997, the 72 cows on the farms delivered 50 calves, calving rate of 0.69, the mortality rate til weaning is 10%, therefore the productivity rate is 0.62. The daily weight gain of calves between birth and 12 months is 420 g to 536 g per day.

4.3 Socio-economic impact on hair sheep keeping

Animal husbandry has several functions in farming systems of Sucumbíos. Cattle keeping has mainly an economical function, hair sheep keeping a subsistence and on-farm links´ function. The dung of sheep (not from cattle) is used as fertilizer, the grazing in the coffee and cocoa plantations reduce the clearance efforts.

The work in husbandry is carried out by the whole family. The labour needed for the stock on the chosen farms of about 17 cattle (3 dairy cows) and 13 hair sheep was 3 hours 48 minutes d^{-1}. About 3 hours 24 minutes are needed for the cattle including the milking and just 36 minutes for the sheep. The men do 44% of the work in cattle and sheep keeping, the women 30% in cattle and

24% in sheep keeping and children 18% and 32% respectively. Per LU more labour is needed for sheep than for cattle.

Table 3: Functions of cattle and sheep in the animal holder households in following order of importance

Cattle keeping	hair sheep keeping
1. income	1. subsistence on meat
2. savings	2. on-farm links (dung and clearance)
3. risk reduction	3. savings
4. status	4. income
5. subsistence on milk	5. risk reduction

Table 4: Annual labour needs per livestock unit and production pattern in cattle and hair sheep keeping

Animal husbandry system	labour per LU a^{-1}
Cattle keeping	
• dairy cows and beef production	52
• beef cattle fattening	17
Hair sheep keeping	
• as in FS 1	68
• as in FS 2	32
• as in FS 3	62
• as in FS 4	32

The economic result of sheep keeping is different between the different farming systems. Although the turnover is similar (130,000 Sucre ewe^{-1} a^{-1}), the proportional and semi-fixed costs determine the marginal income of hair sheep keeping. The shrub browsing and the grazing in the coffee plantations reduced the clearance costs in this cash crop production (FS 3 and FS 4). Hair sheep keeping is most profitable, if semi-fixed clearance costs, stables and fencing are considered. Without these costs the most profitable production pattern is the rotation on *Brachiaria decumbens*-pastures.

Table 5: Marginal income and factor utility in hair sheep keeping for different farming systems (in Sucre)

	Silvo-pastoral		Agro-silvo-pastoral	
Farming system	FS 1	FS 2	FS 3	FS 4
Ewes per ha	17.5	2	2	2
Labour hours per ewe	13,5	11	11	6
Turnover per ewe	128,970	134,980	128,070	132,090

Proportional costs per ewe	82,498	117,860	40,457	67,443
Marginal income per ewe	46,472	17,120	87,613	64,647
Marginal income per ha	813,253	34,240	175,226	129,294
Marginal income per hour	3,431	1,539	7,875	10,379
Investment per ha	5,715,000	797,727	1,003,000	749,221
Internal rate of return in %	3	-17	8	8

The high marginal income per hectare with the farming system 1 is due to the rotational sheep grazing and high stocking rate (3.6 LU ha^{-1} a^{-1}). It shows the high potential for land productivity. Nevertheless, land is not a scarce resource for the farmers but labour and capital. Therefore, the marginal income per ewe and per labour hour is higher in the agro-silvo-pastoral farming systems 3 and 4. The usual sheep keeping is farming system 2 showing the worst marginal income per hectare, labour hour and ewe. The free range grazing of sheep on artificial pastures is only for the advantage of the farmers when cattle keeping is considered. With the implementation of sheep into the artificial pastures the marginal income per hectare and labour hour can be increased (Table 6). Therefore, the additional keeping of hair sheep on the artificial pastures is economically justified. Five ewes and one cow is the best proportion in sustainable pasture management.

Table 6: Marginal income and factor utility in common dairy cattle keeping with and without hair sheep keeping (in Sucre)

Production unit	dairy cattle[1] keeping **without** hair sheep	dairy cattle[1] keeping **with** hair sheep[2]
ha needed	2.5 ha	2.5 ha
labour hours needed	66 hours	122 hours
Turnover	1,340,750	2,021,067
Proportional costs	1,002,962	1,207,293
Marginal income	337,788	813,774
Marginal income per ha	134,043	322,926
Marginal income per hour	5,075	6,636
Investment cost per ha	1,568,182	1,971,040
Internal rate of return	- 8%	6%

[1]Production unit dairy cow: one dairy cow, 0.7 rearing of female calves, 0.3 bull fattening. [2]Production unit hair sheep: five ewes including followers, offsprings and ram.

The farmers´ own production of meat in small (consumable) portions is the main purpose for hair sheep keeping. Small numbers of animals are sufficient to fulfill this purpose. Therefore, only 7 to 8 ewes per farm have a small contribution of about 3% to the total farm income (average figures). It is easy

to increase this number and all farms have free resources in fodder and labour available for this animal husbandry. Capital is the scarce resource. Credits are not available for sheep keeping but for cattle and coffee plantations. Nevertheless, sheep are less expensive than cattle and for poor farmers it is easier to start animal husbandry with hair sheep than with cattle.

4.4 Ecological aspects of sheep and cattle keeping

The vegetation composition on pasture is determined by the selection of the grazing animals, the stocking density, the grazing system and the grazing persistence of the individual plant species. Permanent pasture is the most easy way to keep animals but it causes fodder plant species to disappear with time, especially the ones that are not tolerant to grazing. To avoid such unwanted changes, rotational grazing is recommended. In periods without grazing the vegetation can recover.

On a one year grazing trial on a *Brachiaria decumbens*-pasture with mean stocking densities of 3.6 LU sheep with a grazing rest of only three weeks and a grazing period of one week per rotation, the vegetation composition changes positively toward an encroachment of the cultivated grass *Brachiaria decumbens* and a reduction of *Cyperaceae*. *Brachiaria* species show rapid regrowth and good persistence under frequent defoliation (FISHER & KERRIDGE 1996). A grazing trial with cattle showed at a mean stocking density of 1.8 LU ha^{-1} a^{-1} no significant changes on the vegetation composition, assuming a sustainable carrying capacity.

In agro-silvo-pastoral systems the spontaneous ground vegetation is extremely heterogeneous, thus making rotational grazing more difficult. A grazing trial showed that with a mean stocking density of 1.1 LU sheep ha^{-1} a^{-1} the vegetation composition changes significantly towards less preferred species (less preferred *Panicum stoloniferum* is encroaching, preferred *Dicotyledoneae* is decreasing and preferred and persistent *Axonopus compressus* is stable). Such a mean stocking density is too high for spontaneous ground vegetation (s. Table 1). It is recommended to have a manual clearance every six months thus minimising the competition advantage of not preferred vegetation towards preferred vegetation. Positive effects of rotational grazing with adjusted stocking densities can be assumed to avoid heavy vegetation changes.

Animal grazing has a dominant effect on the movement of nutrients through the soil-plant-animal system. About 60 to 99 % of the ingested nutrients return to the pasture in form of dung and urine, thus provocating a nutrient concentration on the patches of excreta and a translocation of nutrients towards the stock camps (animal housing) (HAYNES & WILLIAMS 1993). The latter is more marked on sheep grazing than on cattle grazing. On a sheep pasture a nutrient gradient between the area of grazing and the stock camps

could be proved. Soil erosion is not a problem in the region. Because of the short period of survey tendencies towards a bigger trampling effect on soil of cattle than sheep could merely be seen.

5 Discussion and conclusion

It can be concluded that hair sheep keeping is possible in climates like the rainforest of Ecuador. The productivity and the health of the animals is sufficient. The people accept hair sheep. Lamb and mutton are also well accepted. Nevertheless, sheep keeping will not substitute cattle keeping which has a higher status.

The ecological effects depend on the management and the frame conditions. The most ecological impact is that hair sheep keeping increases farm income without further deforestation. The sheep use unused resources of fodder and labour.

The implementation into permanent crop plantations is the most profitable and ecologically acceptable keeping measure. On artificial pastures keeping of some sheep in addition to the cattle stock increases the income of the farmers without further cutting down of the rainforest. Sheep have a different fodder spectrum than cattle.

Improvements in hair sheep keeping should focus on animal health, housing, animal nutrition and breeding. Extension efforts should consider the grazing in agro-silvo-pastoral systems. There is need to investigate rotational grazing in this farming system. Mixed grazing on artificial pasture with cattle and sheep is viable and could be improved. Investigation is needed.

To improve the fodder basis for sheep of agro-silvo-pastoral systems, sowing of adapted legumes (e. g. *Arachis pintoi,* compare PIZARRO & RINCÓN 1995) and proliferating grazing resistant spontaneous fodder plants (e. g. *Axonopus compressus*) would be useful. It would also counteract that due to fodder scarceness, bark stripping may occur on permanent crops. To keep/improve the fertility of the soil, the sowing of legumes (*Inga spp.*, *Stylosantes quianensis*, *Centrosema spp.*, *Codarioclyx gyroides*; compare INIAP 1997) and trees, as well as the reincorporation into the pasture of the excretions that accumulate in the sheep housing, would be advisable.

The infrastructure is less developed for hair sheep keeping. The marketing of hair sheep is currently small compared to cattle, but lamb and mutton are being accepted by consumers. The exploring of local demand could help to improve the attitude to hair sheep. The demand of farmers for breeding ewes is high. The local stock however is not able to fulfill this, but in Columbia large flocks exist (1.5 million ewes). The advisory activities and extension servises should be based on a participatory approach. The hair sheep association ACOAS founded in 1997could be the target group as

multiplicators. Nevertheless, capital to buy sheep is the most scarce resource. The opening of the agricultural credits for sheep investments is recommended.

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