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INTENSIFICATION OF LIVESTOCK PRODUCTION SYSTEMS IN THE NORTH WEST REGION OF CAMEROON:

A South-to-South Collaboration for Technology Transfer

The Tugi Silvopastoral Project

FEBRUARY 2012

THE WORLD BANK

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ACKNOWLEDGEMENTS

The Tugi Silvopastoral Project (TUSIP) empirical results and achievements reported here would not be possible without the strong commitment and support provided by His Royal Highness (HRH) Wilson Munoh Mbakwa IV, the fon of Tugi, and his quarter heads. The owners of the pilot farms—Samuel Ane Fongho, Samuel Bangwa, and Abraham Abanda (Bagham Farm); Humphrey Tah, Jonathan Forchit, and Jonathan Nanji (Tah Farm); HRH Wilson Munoh Mbakwa IV, Emmanuel Agwe, and Agnes Mbakwa (Munoh Farm); and Gregory Tebug, Thomas Tebug, and Martin Muna Tebug (Tangyie Farm)—believed in TUSIP innovations, took the risk of the unknown and opened their farms, and worked hand in hand with the project staff implementing the silvopastoral options on their farms.

The support provided and interest expressed by Mr. George Tah, mayor of Mbengwi Council, in the work conducted by TUSIP, as well as his openness to facilitate the contacts with the senior divisional officer for Momo Division and with the local offices of the technical ministries directly related to TUSIP, are highly appreciated.

The dedication of TUSIP technical and administrative staff, as well as the Project Management Committee, under the leadership of Dr. Ajaga Nji, president and founder of Akwi Memorial Foundation (AMF), interacting positively with staff (Muhammad Ibrahim, Danilo Pezo, and Braulio Cerdas) of the Livestock and Environment Program (GAMMA) at the Tropical Agriculture Research and Higher Education Centre (CATIE), contributed to the significant changes being made on the participating pilot farms, despite the relatively short period over which the project operated.

Special recognition is given to Mr. Chick Herman Azah (research assistant), Ms. Doris Ndang (gender specialist), Ms. Catherine Mbinkai Tazuh (gender specialist), Mr. Thomas Tumasang Tebug (consultant in animal husbandry), Mr. Walters Ndibang (field assistant), Mr. Samuel Sabi (driver), and the youth and women's groups for their enthusiastic involvement in the field work. All shared their knowledge, energy, food, and joyful spirit, making the work in the mountains an unforgettable experience. Thanks also to Mr. Martin Mbakwa for the support provided from the AMF Office in Bamenda.

Special thanks to Dr. Jonathan Ndaa Agwe from the World Bank headquarters in Washington, D.C., for the valuable comments and advice made throughout the continuous monitoring of the project. The comments and suggestions made by Dr. Mark Cackler and Dr. Jimmy Smith from the World Bank headquarters in Washington, D.C., during the visit made to TUSIP in October 2010 are also highly appreciated. Dr. Agwe provided the leadership for the technical assistance team, along with fiduciary administration support and coordination of the peer-review process. Jonathan also provided production and initial manuscript editing, while Dr. Amy Gautam provided final manuscript editing and proofreading.

We appreciate the support provided by Dr. Ebenezar Assah and his staff at the World Agro-forestry Center (ICRAF) office in Cameroon and by Dr. Jean Hanson of the International Livestock Research Institute (ILRI). Both contributed germplasm to be evaluated under TUSIP. ICRAF also collaborated in the design of tree nursery facilities and in training farmers in different tree nursery techniques with Mr. Louis Chin as trainer.

The hospitality and friendship offered by all members of the Tugi community helped the technical advisor feel at home, enjoy the work of climbing the hills, and learn about the Meta traditions. The support and assistance provided by Tugians who live in Bamenda during the visits the technical advisor made to the city are also greatly appreciated.

Finally, we acknowledge the World Bank's Trust Fund for Environmental and Socially Sustainable Development for their sponsorship of the pilot whose results we share in this report.

ABBREVIATIONS

AMF	Akwi Memorial Foundation
AU	Animal unit
BW	Body weight
CATIE	Tropical Agriculture Research and Higher Education Centre
CEC	Cation exchange capacity
CGIAR	Consultative Group on International Agricultural Research
CIP	International Potato Center
CP	Crude protein
DM	Dry matter
ECAG	The Central American School for Livestock Production
FCFA Africaine	Franc de la Communauté Financière
FFS	Farmers Field Schools
GAMMA	Livestock and Environment Program (Ganadería y Manejo del Medio Ambiente, in Spanish)
HPI	Heifer Project International
HRH	His Royal Highness
ICRAF	World Agro Forestry Center
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IRAD	Institute de Recherche Agricole pour le Développement
IRR	Internal rate of return
LIFE-SIM	Livestock feeding strategies simulation model
LWG	Live weight gain
MASL	Meters above sea level
MECUDA	Meta Cultural and Development Association
NGO	Nongovernment organization
NWR	North West region
PES	Payment for environmental services
PMC	Project Management Committee
PNV	Present net value
PRTC	Presbyterian Rural Training Center
SODEPA	Société de Développement et d'Exploitation des Production Animales
TDN	Total digestible nutrients
TUSIP	Tugi Silvopastoral Project
USAID	U.S. Agency for International Development

EXECUTIVE SUMMARY

The Tugi Silvopastoral Project (TUSIP) is a South-South Cooperation between the Tropical Agriculture Research and Higher Education Centre (CATIE) based in Costa Rica (www.catie.ac.cr) and the Akwi Memorial Foundation (AMF) based in the North West Region of Cameroon. It is a World Bank–supported initiative (www.worldbank.org/ard) that started in Tugi Village in January 2010, and this report covers the 22 months of operation agreed to between the executing agencies and the donor.

The Project's Approach: The main goal of TUSIP was to assess the environmental benefits of a set of silvopastoral practices and to empower traditional livestock farmers in Tugi Village by enhancing their capability to manage available crop-animal systems and natural resources in a sustainable manner. TUSIP made efforts in the rehabilitation of degraded pasturelands to ensure adequate year-round availability of forages to increase animal productivity in a sustainable manner, consequently contributing to improving the livelihoods of rural families who depend on livestock activities in Tugi. The project put emphasis on (1) modifying the traditional crop-livestock systems through the implementation of silvopastoral options, which helped to diversify income sources, and (2) improving soil fertility, while (3) restoring ecosystem services that were affected by the change in land use from forests to degraded pastures. The project applied participatory methodologies to build the capability of the Tugi population to replicate the technological innovations introduced by TUSIP.

Methodological Aspects: The project started with characterization of the prevalent socioeconomic, ecological, and biophysical conditions, emphasizing constraints and opportunities, using different methodological tools according to the attributes being analyzed. In addition to reviewing the secondary information available, project staff applied rapid participatory rural appraisal, household surveys, and focus group discussion techniques to define the socioeconomic baseline conditions to understand the rationale behind the predominant crop-livestock system and to learn about the endogenous and exogenous factors affecting their performance. Soil fertility and land-use management analyses, as well as pasture degradation evaluation methods, were applied to assess the current status of the pasturelands and define strategies for their rehabilitation. A set of technology innovations initially tested and promoted in Central America was adapted and evaluated under the conditions of the Gutah Hills of Cameroon.

The technology innovations that were tested for the rehabilitation of degraded pasturelands were based on restoration ecology principles but were applied to pasture agro-ecosystems. These innovations included promotion of edible species through oversowing of valuable grasses and legumes, control of competition by nondesirable weeds, and exclusion of grazing animals for a reasonable period of time to promote the dominance of valuable forage species through vegetative growth, flowering, and enrichment of seed banks that eventually emerged. Prevention of accidental fires through fire-tracing measures was also introduced. Once pastures recovered their productivity at least partially, well-designed rotational grazing systems were initiated. Some of these processes required construction of dead fences—a technology innovation not yet used in the Gutah Hills—while at the same time, efforts were made to incorporate trees in multistrata live fences.

TUSIP also established grass/legume fodder banks to intensify crop-animal systems through implementation of semi-zero grazing systems for cattle and small ruminants. For that purpose, designs of corrals for cattle and elevated pens for small ruminants were proposed and built by farm operators and women's groups, respectively.

The investment required for all innovations was recorded by TUSIP technical staff, and an *ex ante* analysis of the impact of pasture management innovations was conducted using the LIFE-SIM model; a cost-benefit analysis was also conducted,

assuming that real data on animal performance will be collected and made available after animals are introduced in the paddocks, which was expected to occur in the second half of the 2011 rainy season.

Most Relevant Empirical Results Due to Technology Innovations: The project duration was not long enough to measure plant, soil, and animal responses to silvopastoral innovations, although relevant changes in vegetation composition and availability were observed and recorded. Based on the limited results collected in the field and on a simulation analysis, it was estimated that for growing animals (with 200 to 400 kg of body weight [BW]), production per hectare would increase up to six times if animals had access to rehabilitated pastures and up to ten times if fodder banks were used to supplement grazing in the rehabilitated pastures during the dry season. The increment in productivity would be a little less if those silvopastoral systems were applied in the finishing phase of cattle (that is, 400 to 500 kg BW). The age at which animals reach market weight (500 kg BW) would be reduced from 7.2 years, currently obtained with the traditional system, to 4.9 and 4.1 years in rehabilitated pastures without and with the utilization of fodder banks, respectively. These innovations would also result in a significant reduction in methane emissions and total nitrogen excretion over the cattle's life span.

The economic assessment of those interventions showed that rehabilitation of degraded pastures resulted in a negative (–2.95 percent) internal rate of return (IRR) when pastures were grazed by growing animals (200 to 400 kg BW), but the IRR increased to 9.09 percent when pastures were supplemented with the fodder bank. The major cost associated with the use of rehabilitated degraded pastures is the investment in fences. Therefore, a sensitivity analysis was conducted assuming that the costs of fences were either partially (50 percent) or fully (100 percent) subsidized. In the case of growing animals not supplemented with cut-and-carry forages, the IRR increased to 5.50 and 30.68 percent, respectively. When subsidies were applied to the investment in fences and using growing animals, the IRR increased to 15.71 and 26.65 percent, if 50 or 100 percent of the investment in fences incurred during the project.

Strengthening Capabilities of Local Partners: In parallel with implementation of the technologies described above, TUSIP developed an effective training program, applying the participatory methodologies that are the basis of the Farmers Field School (FFS) approach. Farm operators, youth, and women's groups participated in those trainings. TUSIP proposed to continue the training on topics identified as relevant but not yet covered. To support the training activities, extension leaflets and bulletins (three of each) were prepared based on the experiences of TUSIP in fence building, bracken fern control, and grass/legume fodder banks establishment.

Project staff (the technical and field assistants and the gender specialists) were also trained by CATIE's technical advisor on different topics, such as silvopastoral technologies and participatory research and training methodologies. The technical assistant participated in a three-week one-on-one training course in Costa Rica, during which he participated in individual lectures on the implementation and evaluation of silvopastoral options and was introduced to computer packages for the simulation of feeding strategies, as well as Geographic Information System techniques. This was complemented with farm visits to learn about several silvopastoral options already implemented by farmers in the humid, subhumid, and highland tropics of Costa Rica.

Livestock Farmers' Perceptions of Technology Innovations: An effort was made to understand farmers' perceptions and expectations of the silvopastoral innovations promoted by TUSIP; however, this was a preliminary activity covering only aspects related to installation of the technologies. All stakeholders recognized the advantages of the proposed innovations in increasing the availability of edible grasses and legumes, reducing the infestation of bracken fern and other problematic weeds, and controlling erosion. However, similar studies need to be done again after the innovations have been applied for at least one year covering both the rainy and dry seasons. Other perceived benefits of TUSIP efforts were creation of field work opportunities for youth and women and development of new skills that could help them replicate the lessons learned.

Budget Execution: The contribution of the World Bank for implementation of TUSIP was USD 195,000, officially received by CATIE. According to project planning, 56.4 percent of that was transferred to the AMF in three installments for TUSIP operation in Cameroon. However, 90.6 percent of the amount assigned to CATIE was also spent in Cameroon. Budget execution was 100 percent, with slight underexpenditure in local consultant fees and minor overexpenditures in dissemination and other items.

Final Comments: In the Gutah Hills, deforestation and soil degradation are seriously affecting the productivity of the prevalent crop-animal systems and the livelihoods of local communities. Water availability is not a limiting factor yet, but its quality is already a problem. The nonsustainable land-use management practices currently applied jeopardize the resilience of these systems under climate change conditions. The silvopastoral innovations promoted by TUSIP included options to rehabilitate degraded lands, increase animal productivity, reduce the time required for animals to reach the market, mitigate the emission of greenhouse gases per kilogram of animal product and per animal life span, increase the potential for carbon sequestration, and, more importantly, contribute to improving the livelihoods of farming communities.

The main constraint to implementation of these innovations is capital availability for investment. Subsidies or payments for ecosystem services schemes may be necessary. Also, the application of participatory learning and experimentation approaches, such as FFS, and effective involvement of existing groups in training, production, and transformation processes, are means of contributing to alleviating poverty in rural communities.

The nature of the problems faced by farmers requires a holistic approach and integration of stakeholders with different backgrounds and interests (including government and nongovernment organization [NGOs] and local leaders) working together for development. South-South cooperation efforts like TUSIP can help find solutions, especially given the similarities among tropical countries in terms of agro-ecological conditions and production systems and the global threat of climate change.

The Way Forward: TUSIP raised the awareness of stakeholders, including government institutions, NGOs, local leaders, farm operators, the entire Tugi population, and leaders of neighboring communities of the objectives and activities developed by the project. Partnerships were promoted with several regional and national institutions, as well as with two Consultative Group on International Agricultural Research (CGIAR) centers (the International Livestock Research Institute and the World Agro-forestry Center). This enhanced the interest of partners in scaling TUSIP experiences up and out to other areas of the Gutah Hills, where they could be easily extended. Important issues consolidated into an appendix to this report were raised by peer reviewers, and the issues will have to be addressed, resources and time permitting. As a result of such efforts, a concept note titled "Increasing Productivity and Reducing Vulnerability to the Climate Change as Strategies to Improve the Livelihoods in Poor Agro-Silvopastoral Communities of the Gutah Hills of Cameroon" was prepared, and CATIE, the World Bank, and other partners started contacting potential donors.

Chapter 1: INTRODUCTION

1.1 THE GENERAL CONTEXT

Gutah Hills is a local name for the human settlements located on the northwestern plateau of the Meta Clan in the Momo Division (North West Region [NWR]) of Cameroon. Three villages (Tugi, Ngwokwong, and Chup) make up the geographical area called Gutah as defined by the Meta Cultural and Development Association (MECUDA). Administratively, each village is ruled by a village head called a chief or fon, and the village is made up of quarters, placed under the local administrative leadership of a quarter head who reports to the fon. At the lowest rung of the administrative ladder of a village are heads of households or family heads. The family is the basic social unit in these villages.

In terms of land ownership and control, in theory, the Cameroonian government *owns* all land; however, the fon is the *owner* or *landlord* of all land inhabited by his people and is considered the *custodian* of all native or communal land. Transfer of land ownership in the Gutah Hills, as in most of Cameroon, takes several forms including inheritance, purchase, gift, and lease. More details on policies applicable to the rural sector of Cameroon and relevant to TUSIP can be found in the report on the gender component of this project (Ndang *et al.* 2011).

1.2 HUMAN SETTLEMENT IN THE GUTAH HILLS

Native human settlements in the Gutah Hills go back to the 13th century, when explorers and clan heads conquered hitherto unoccupied territory. Gutah villages have several neighbors. Tugi Village, for example, shares its southern boundaries with Tudig and Njah-Etu; to the southwest is the neighboring village of Ngwokwong, while Tinechong is to the northwest. To the north is Oshie, and to the east are the villages of Chup and Guneku (Nji *et al.* 2009).

The population of the Gutah Hills includes the indigenous people of the Meta clan and the Fulanis (Mbororos). The latter used to practice nomadic pastoralism but were encouraged by the government to adopt a sedentary lifestyle (figures 1.1 and 1.2). For that purpose, in the 1960s, the Fon of Tugi allocated some of the hills in his village to the Fulani people to carry out their livestock activities (Nji 1995). These two groups have different traditions and beliefs but interact in the use of local land and services (for example, education and health), as well as in the market.

The Meta people settle in compound villages composed of large and uneven parcels of farmland around and farther away from the residential areas. The farmlands around the homestead are small parcels reserved mostly for fruit production (such as plantain, avocados, and coffee), while farmlands away from home are larger and are used to cultivate roots and tubers (such as yams, cocoyams, cassava, Irish potatoes, and sweet potatoes) as well as grains (such as maize and beans) for home consumption and the market (figure 1.3). The choice, location, and use of farmland are based on the

FIGURE 1.1: World Bank Staff on Mission and Group of Meta People Who Participated in Project Activities

Source: Authors.

FIGURE 1.2: Group of Fulani Men Visited by TUSIP Staff

Source: Authors.

FIGURE 1.3: Meta Woman Working Her Cropland

Source: Authors.

indigenous knowledge system, which enables the Meta to distinguish farmland suitable for different uses. Each family cultivates several plots under a shifting cultivation scheme according to its appreciation of the soil fertility status. However, due to recent population increases, more pressure is being exerted on the land, and the fallow period is becoming too short to booster soil fertility, affecting the productivity of the soil and threatening the livelihoods of the local population.

The Fulani live in isolated round or circular compounds perched on the hills, which serve as residential areas for families and grazing areas for the animals. Nomadic pastoralism or transhumance is still practiced by Fulani livestock farmers, with young family members moving part of the herd during the dry season (December to March). Crop production by Fulani families is very limited, occurring in plots around their homesteads that have been enriched by manure deposited by animals kept at night as a preventive measure against cattle rustling. It can be claimed that both the Meta and Fulani people practice agro-pastoral farming systems, although the relative importance of each component differs between the two ethnic groups.

Although men and women participate in all agricultural activities, sex-role typing is prevalent in both ethnic groups. In general, men tend to be responsible for raising cattle and pigs and helping to prepare land, while women are responsible for cultivating crops, raising small ruminants (such as goats and sheep), and taking care of the family (Ndang *et al*. 2011). In the case of the Fulanis, women milk the cows, while Meta men collect raffia juice to produce wine. In order to be inclusive in its approach, TUSIP recognized such diversity and tried to identify specific participatory learning and experimentation activities for each gender and ethnic group.

1.3 LIVELIHOOD STRATEGIES IN THE GUTAH HILLS

Crop-livestock systems are the most prevalent agricultural land-use systems in the Gutah Hills and the main livelihood strategy, especially for Meta families (Ndang *et al*. 2011; Pezo 2010a), whereas Fulanis earn their living almost exclusively from raising cattle, goats, sheep, and horses in a free-ranging farming system in the hills. Several reasons are behind diversification of farming activities as practiced by the Meta people, including the reduction of economic risk and provision of a more diverse diet, particularly from food crops (figure 1.4) (Ndang *et al*. 2011). Nontimber forest products such as kolanuts and raffia juice are also important contributors to the livelihoods of the Meta people in Tugi.

There is room for intensifying interactions to enhance the productivity of both crop and livestock, as well as to cope with climate change. These interactions include the collection and return of manure for improving soil fertility in farmlands and use of the weeds and nonmarketable agricultural by-products as animal feed buffers, particularly for those periods when pasture availability is limited.

Regardless of ethnicity, livestock production constitutes one of the main pathways used by poor households in the Gutah Hills to accumulate capital and assets, and it can be crucial in maintaining household survival in times of crisis and in changing the household's social status. The same applies to other areas of Sub-Saharan Africa (figure 1.5). However,

FIGURE 1.4: Fulani Herdsman Controlling Grazing Animals

Source: Authors.

FIGURE 1.5: Meta Boys Taking Their Goats for Grazing

Source: Authors.

the combined threat of food insecurity, undernutrition, poor health conditions, and climate change act as additional stressors on these rural communities, further limiting their coping ability and adversely affecting poverty eradication efforts.

Pastures are the main land-use system in the NWR of Cameroon, and cattle production is managed using traditional technologies in an extensive agro-pastoral system that results in soil fertility decline, poor crop-tree-livestock integration, and increased encroachment on fragile and protected areas (figure 1.6). More importantly, poor pasture management has resulted in frequent conflicts between herders and farmers (Harsbarger and Nji 1991). Moreover, severe land degradation

FIGURE 1.6: Fulani Girl Helping the Family Graze Cows

Source: Authors.

has occurred over the years due to the continuous increase in livestock density on pasture lands amidst the backdrop of climate change and variability. This is a consequence of the poor pasture management technologies used, including overgrazing (particularly during the dry season) and the use of fire to control weeds and external parasites in cattle and to eliminate overmatured grasses and residues left after grazing (Njoya *et al.* 1999; Pamo 2011; Pezo and Azah 2010a). This results in poor soil cover, which in turn makes the land more prone to erosion.

The situation has also resulted in negative effects on the ecosystem's capacity to provide environmental services (especially carbon sequestration, clean water provision, and biodiversity), as well as in detrimental impacts on food security and the livelihoods of the communities that manage those land resources. Moreover, the decline in soil fertility is becoming more critical because using fertilizers is not a common practice and grazers are not familiar with the value of legumes and trees for soil improvement through more effective nutrient cycling.

Livestock production has frequently been cited as harmful to the environment, and livestock farmers have been accused of causing deforestation, desertification, and pollution and of contributing toward global warming through ruminants' emissions of greenhouse gases. However, recent evidence suggests that such accusations are simplistic and misleading, as environmental damage by livestock is more a reflection of the way people manage their animals. In that sense, many researchers (Ibrahim *et al.* 2011) consider the integration of animals, crops, and trees in agro-silvopastoral systems an essential prerequisite for sustainable land use and diversification of farm produce and a means for improving food security and alleviating poverty. In summary, if properly

managed to cope with the impacts of climate change by applying agro-silvopastoral approaches, these systems could result in improving rural livelihoods and ecosystem health.

Enhancing livestock productivity in communities will increase the availability of animal protein, improve household nutrition especially for children, and increase income. All of these positive impacts would in turn result in improved livelihoods for poor families. The traditional diet relies mostly on grains, tubers, vegetables, fruits, and limited amounts of animal protein (mostly meat and fish, as well as milk for the children). The low contribution of animal protein to the diet of the rural population is mainly due to limitations in affordability and availability in local markets. Consequently, people do not get enough of the essential amino acids, fatty acids, macro-minerals, and micronutrients that are required for improved growth and development of robust immune and cognitive systems and for the overall health of young children (de Pee *et al.* 2010; Santika *et al.* 2009).

1.4 MARKETING FARM PRODUCE

Access to markets is an additional limiting factor in the Gutah Hills. Although there is a local cattle market in Acha-Tugi (Pezo and Azah 2010b), the whole negotiation process is based on the appearance of the animals, and most animals are bought by middlemen who take them to larger markets, such as the one in Bamenda (figure 1.7). By doing so, the middlemen get the better part of the margin that accrues between when the farmer makes the sale and consumption. There is strong demand for smoked beef in the large cities, such as Douala; therefore, some people in the village do processing almost once a week, but there is no classification for cuttings and the smoking process is quite rudimentary, resulting in poor product quality. As with fresh meat, middlemen take the product to the cities, again keeping most of the profit margin for themselves.

The lack of transportation facilities, adequate roads, and strong farmers' organizations leads farmers to sell their crops primarily in the villages' weekly markets; occasionally, part of the produce is taken to the regional market in Tad (about 20 km from Tugi-Tugi) where better prices can be obtained, but farmers have to pay high transportation fees and spend the whole day in the market (figure 1.8). As the purchase capability and demand in the village are limited and crops are perishable, itinerant intermediaries (both men and women) usually buy the crops at very low prices. Lack of proper processing equipment and facilities for crops further limits the possibility of adding value to the crops produced (Ndang *et al.* 2011).

FIGURE 1.7: Inspecting Animals and Then Negotiating Prices at a Tugi Local Cattle Market

Source: Authors.

FIGURE 1.8: Women Selling Their Crops in the Tugi Local Market

Source: Authors.

Chapter 2: OBJECTIVES OF THE TUSIP PROJECT

Based on the prevalent conditions identified in Tugi Village, the main goal of TUSIP was to assess the environmental benefits of a set of silvopastoral practices and to empower traditional livestock farmers in the village by enhancing their capability to manage their farms and natural resources in a sustainable manner through participatory training and experimentation. In this context, this report describes the efforts of TUSIP to encourage rehabilitation of degraded pastures and implementation of silvopastoral options to ensure adequate year-round availability of high-quality forages as the basis for improving animal productivity. At the same time, this would help prevent environmental degradation due to overgrazing. It was anticipated that such TUSIP-induced pasture management changes would eventually result in restoring the ecosystem services affected by the change in land use from forest to degraded pastures.

The specific objectives of the project are summarized as follows:

1. Build the indigenous capacity of livestock farmers in the community to identify, understand, and examine the dynamics of the livestock production and environment interactions under the current traditional farming systems.
2. Develop farmers' skills and competencies so that they are able to assess the environmental costs of traditional management and the potential and real benefits of improved livestock production applying silvopastoral options.
3. Understand farmers' perceptions and expectations of environmental effects and consequences of climate change on their livelihoods.
4. Train farmers on the application of a set of silvopastoral technology innovations and encourage their adoption within the crop-livestock systems they practice.
5. Encourage integrated management of grazing lands in Tugi Village to ensure adequate year-round availability of high-quality forages for improving animal productivity.
6. Contribute to finding sustained solutions to the chronic problem of farmer-grazer conflicts and cattle rustling in the area, as well as to environmental problems due to overgrazing.
7. Propose a means to scale up the project to other communities in the Gutah Hills and other regions with similar agro-ecological and production conditions within Cameroon.

Chapter 3: METHODOLOGICAL APPROACH

TUSIP was executed applying participatory methodologies as much as possible, such that beneficiaries were key actors in all levels of project implementation. Four livestock family farms and one community farm were selected to test improved technologies over 22 months, from January 1, 2010, to September 30, 2011. The pilot farms were specifically selected to represent the ecological pattern of the entire village, taking into account differences in farm resources, landscape characteristics, and agro-ecological conditions. However, the work carried out in those farms was intended to benefit not only the owners, but also the whole community, because those farms were used as *laboratories* for group participatory learning and experimentation purposes.

In the pilot farms, principles of restoration ecology for the rehabilitation of degraded pastures were applied, as were improved pasture management and silvopastoral technologies that had proven successful in other projects developed by the Tropical Agriculture Research and Higher Education Centre (CATIE) and its partners in Latin America. These were the basis for the intensification and diversification of the crop-livestock production systems practiced in the pilot farms. In that sense, the project was a unique effort of South-South cooperation in technology transfer between CATIE (a research and training center based in Costa Rica but with a Central American regional coverage), the Akwi Memorial Foundation (AMF; a Cameroonian not-for-profit organization based in Bamenda, NWR of Cameroon), and the population of Tugi Village.

The target audience included primarily the farmers of Tugi Village who practice mainly crop-livestock systems, and the project applied a women-sensitive mainstreaming model intended to cover the following specific activities:

1. Collect, collate, and analyze baseline technical and socioeconomic data for all farms wherein the principal farm operator was the unit of analysis.
2. Establish improved silvopastoral and agro-forestry technologies in four pilot family farms and one community farm. These five farms were chosen on the basis of their geographical and ecological representativeness, social soundness, and economic feasibility. Of great significance for cultural relevance and environmental protection was the inclusion of the community farm, which contains the Gyindong Forest Reserve of Tugi Village. Each of the pilot family farms was under the leadership of a family head, while the community farm was under the leadership of the Tugi Fon, the traditional custodian of the village/community land.
3. Train farmers and livestock keepers on the improved technologies promoted by the project, and assess their attitudes, perceptions, and adoption patterns.

The project was designed to benefit not only Tugi villagers, but also some farmers of neighboring communities and staff of government institutions, academia, and NGOs (such as the Presbyterian Rural Training Center and Heifer Project International [HPI]–Cameroon) who could learn about the technologies and methodological approaches applied by TUSIP.

Chapter 4: BASELINE HOUSEHOLD AND FARM CHARACTERIZATION

After analyzing secondary information and a Rapid Rural Appraisal effort including reconnaissance trips, the project staff decided to apply two methods for collection of the baseline socioeconomic information on households and crop-livestock systems practiced in Tugi Village, as well as to identify their constraints and opportunities: (1) a survey of a sample of households/farms using a structured questionnaire and (2) focus group discussions with representatives of a sample of quarters. For the survey, ten livestock farmer families were interviewed using a livelihood strategies–oriented questionnaire (figure 4.1). The survey included the five pilot farms (P) chosen for implementation of silvopastoral interventions (all owned by Meta families), and five livestock farms (three owned by Meta and two by Fulani families) considered control farms (C). One of each of the P and C farms are located in Tuochup Quarter in Chup Village, and the rest are in Tugi Village (Tugi-Tugi, Acha-Tugi, and Njaa-Tugi Quarters). The sample size is small, but the farms chosen represent the majority of farms owned by Meta families in Tugi who have cattle and only a small number of the ones owned by Fulani families.

FIGURE 4.1: Research Assistant Interviewing a Family Head

Source: Authors.

At the beginning, it was not possible to gather details for all variables included in the questionnaire, particularly those related to animal inventory and productivity of the crop and livestock components, as farmers in general do not keep records. Therefore, a few weeks after the initial survey effort, the project team arranged a second visit to get the missing information. Questions were formulated in a more informal manner, as part of a conversation, to help farmers provide the answers. As the second interview was conducted after the project had initiated some field activities, more confidence was built between the project staff and community members, particularly the pilot farm operators. The quality of the information gathered improved, but it was still almost impossible to get reliable quantitative data on crop-livestock productivity. An analysis of the information gathered in the household survey of pilot and control farms was included in the first Interim Consultancy Report (Pezo 2010a).

Later, when the TUSIP Gender Mainstream Component was started, more detailed information related to the crop and small animal components, as well as to gender roles, was obtained using a specific questionnaire, but this also failed to obtain reliable productivity parameters (Ndang *et al.* 2011).

In the case of the focus group workshops, discussions were held with representatives of three relatively homogeneous groups, two of them with a majority of Meta people, and the third composed of only Fulanis (figure 4.2). In the case of the workshops held with the Meta-dominated groups (Mbengap and Tuochup Quarters), men and women participated in the discussions, whereas in the one with the Fulanis (who identified themselves as part of the Nkun-Fonaba group, which is located close to the Acha-Tugi cattle market), the family leader decided that only men should attend the workshop. The main difference between the focus group discussions and the household survey was that the former concentrated

FIGURE 4.2: Focus Group Discussion with Quarter Representatives

Source: Authors.

more on community-based perceptions while the latter reflected the perceptions of each family head interviewed.

The questionnaire used for the focus group discussion covered diverse aspects such as population, livelihood strategies, land use, water availability, access to markets and credits, food insecurity, perceptions of land degradation and climate change, technology innovations introduced, sources of information, types of organizations in the project community (Tugi Village and the Tuochup Quarter in Chup Village), knowledge about national and local rules and regulations and how those affect the prevalent production systems, and natural resource management. In many cases, emphasis was placed on the current situation and changes that occurred in recent years with group members. Most of the problems and opportunities identified in previous studies, as described in the introduction, were confirmed. Participants in the focus groups were asked to rank the constraints they felt were most relevant (see table 4.1). The independent responses provided by each participant were classified by gender in the two quarters where both men and women participated in the workshops; relevant differences can be noted.

There were some differences between quarters and gender groups in the ranking of constraints. For all groups, the access to markets, in part associated with the quality of roads, was more important than the prices obtained; this type of problem was more relevant for the people of Tuochup than for the other two groups. Diseases were identified as a relevant limiting factor by women in Tuochup and Mbengap and by men only in the case of the Nkun-Fonaba group. This is understandable given that in the former two quarters (with a majority of Meta people), they were referring to crop disease, and crop work is mostly conducted by women, whereas in the latter, which is dominated by Fulanis whose men tend to the animals, they were referring to animal diseases. Capital for investments was cited by all groups but was not one of the main limiting factors given the extensive nature of the systems practiced. However, all groups recognized that capital would be a limiting factor for any intensification effort.

TABLE 4.1: Ranking of Constraints Identified by Male (M) and Female (F) Interviewees in Two Quarters of Tugi Village and One Quarter of Chup Village

	TUOCHUP (CHUP)		MBENGAP (TUGI)		NKUN-FONABA (TUGI)
CONSTRAINTS	M	F	M	F	M
1. Prices of products	0.50 [b]	0.00	0.45	0.00	0.00
2. Market problems	3.00	3.00	1.55	1.70	1.36
3. Diseases (plants and/or animals)	1.00	4.33	1.55	4.10	3.55
4. Security	0.83	0.33	2.45	1.20	1.09
5. Capital for investment	0.00	1.33	1.09	1.00	1.41
6. Poor roads	3.67	0.00	1.91	1.00	1.45
7. Feeding animals[a]	—	—	—	—	0.09
8. Water[a]	—	—	—	—	0.05

[a] Constraints mentioned only by the Fulanis.
[b] The mean values are based on a scale ranging from 1 to 5, according to the perception of each participant on the relevance of the constraint, 5 being the most limiting.
Source: Authors.

Chapter 5: ESTABLISHMENT OF SILVOPASTORAL TECHNOLOGIES

5.1 REPRESENTATIVENESS OF THE PILOT FARMS

Four livestock family farms (Munoh, Tangyie, Tah, and Baghan) and one community farm (Gyindong) were chosen to test improved silvopastoral technologies. In selecting the farms, the variability in elevation and farm resources, as a means of representing the ecological pattern of the entire village, was considered; this will eventually facilitate the replication of experiences elsewhere in Tugi Village, as well as in other villages in the Gutah Hills. Two of the family farms and the community farm are located in Tugi-Tugi; one family farm is located in Acha-Tugi, and another is in Tuochup (table 5.1). The elevation at these farms ranges between 1,540 and 1,985 m above sea level (MASL), a range that covers most of the grazing areas in Tugi and Chup villages.

During a brief reconnaissance visit, all areas proposed by farm operators and other local stakeholders for implementation of the technology innovations were found to be adequate considering their pasture degradation status; this was confirmed later by a more detailed evaluation. In general terms, project staff agreed with the areas chosen but proposed a few changes in the specific location and size of some of the areas to be intervened, particularly for fodder banks, where distance to the corrals, access to water, and the number of animals to be fed when the technologies would be evaluated were deemed important, among other criteria. In all cases, those aspects were discussed with farm operators and other project decision makers.

The areas selected for implementing the interventions, fenced to prevent animals from grazing, varied from 0.9 to 4.4 hectares (ha) for the grazing-only areas and from 0.4 to 0.5 ha for the cut-and-carry areas. On the Gyindong Community Farm, an area of 32.0 ha was fenced, but not all of that was used for establishment of the grazing and fodder bank interventions as there are plans to implement other innovations there, including some agro-forestry options (figure 5.1).

5.2 SOIL FERTILITY IN PASTURES CHOSEN FOR INTERVENTION

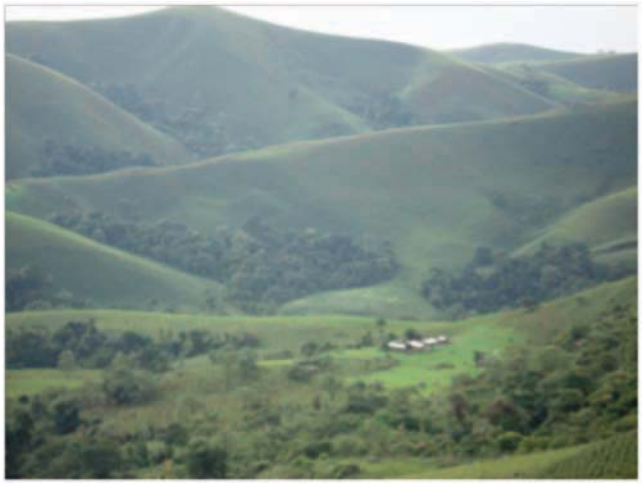
Project staff decided that before implementing any strategy for the rehabilitation of degraded pastures or establishing improved pasture management and other silvopastoral technologies, it was necessary to learn about the soil fertility characteristics and to evaluate the degradation condition of those pasturelands selected by project stakeholders prior to the arrival of the technical advisor assigned by CATIE (figure 5.2). Therefore, in January 2010, soil samples were collected in all pastures to be intervened, coordinated by a World Bank field mission, and sent for laboratory analysis at the State University of Dschang.

TABLE 5.1: Location of Pastures in Pilot Farms Selected for Implementation of Silvopastoral Options

LOCATION	FARM NAME	TYPE OF PROPERTY	ALTITUDE, MASL	GRAZING AREA, ha	CUT-AND-CARRY AREA, ha
Acha-Tugi	Baghan	Family	1,570	1.1	0.4
Tugi-Tugi	Munoh	Family	1,760	4.4	0.5
Tugi-Tugi	Gyindong	Community	1,540	32.0	1.0
Tuochup-Chup	Tah	Family	1,985	0.9	0.5
Tugi-Tugi	Tangyie	Family	1,765	2.0	0.5
	Total			40.4	2.9

Source: Authors.

FIGURE 5.1: A Landscape View of the Community Farm (Gyindong) in Tugi Village



Source: Authors.

FIGURE 5.2: Native Cattle Grazing in Degraded Pastures

Source: Authors.

Soil analysis showed that the soils were acidic (pH 5.26 to 5.56), but their aluminum content was not a problem; it was not even detected in two of the five farms. Phosphorus (P) was deficient in all farms (less than 5 ppm), but the relatively high cation exchange capacity (CEC), which in two of the farms was more than 20 meq/l, suggests that the potassium content is probably high, whereas calcium and magnesium may not be high given the acid reaction of the soil (table 5.2). The average nitrogen (N) content was high in two of the farms (Gyindong and Tah), because some of the samples were taken in areas with high organic matter content and good pasture cover, probably due to high accumulation of manure as animals tend to be maintained there overnight to prevent cattle rustling and to allow the Fulanis to milk the cows early in the morning. This effect was particularly evident in the community farm where samples were taken in three different sites—one close to the herdsman's house where animals are maintained at night and two in open areas with variable cover of pastures and weeds. In that case, the CEC, N, P, and Al ranged between 7.6 and 43.12 meq/L, 0.26 and 1.12 percent, 0.63 and 2.50 ppm, and 0.00 and 2.12 ppm, respectively (table 5.2).

Soil analysis results, along with the pasture degradation results presented in section 5.2, were the basis for the definition of the silvopastoral interventions implemented, the selection of areas where they were established, and for planning the distribution of paddocks. For example, the deficiency of phosphorus in soils usually triggers phosphorus deficiency in forages and may explain the reproductive failures detected in cattle in the Tugi area, where mineral supplementation is seldom practiced. In fact, most livestock farmers declared that they used only common salt as a supplement and not continuously. Also, in the absence of mechanisms to collect enough manure to be incorporated into the soil as part of the rehabilitation strategies and to enrich the areas planted with a grass and legume mixture as fodder bank, it was recommended to apply low doses of a phosphorus-rich fertilizer, particularly to help the legumes to compete favorably with the grass during the establishment phase. Also, a slight application of nitrogen was proposed to accelerate the establishment of the grass and legume planted in the fodder bank areas.

5.3 PASTURE DEGRADATION ASSESSMENT

At the end of the dry season (March 2010), the level of pasture degradation was evaluated by applying the methodology developed by CATIE (Betancourt *et al.* 2007) using the parameters shown in table 5.3.

According to the botanical composition estimates made in March 2010, as shown in table 5.4 (Pezo and Azah 2010a), the percent of edible grasses varied between 16.5 (Baghan farm) and 47.6 percent (Tangyie farm), whereas the average cover by legumes was only 2.9 percent, varying from 0.5 percent in the farm that had the highest presence of edible grasses (Tangyie farm) to 6.9 percent in the one at the highest elevation (Tah farm). Some of the grass species found in the different pastures under evaluation were kikuyu grass (*Pennisetum clandestinum*), star grass (could be either *Cynodon nlemfuensis* or *C. plectostachyus)*, *Brachiaria ruziziensis,* and *Hyparhenia rufa*. Among the legumes, there were native *Trifolium* spp., *Desmodium uncinatum* var. *Silver leaf,* other nonidentified *Desmodium* spp., and also some

TABLE 5.2: Attributes of Soil Samples Taken in Farms Chosen for Implementation of Silvopastoral Options in the Pilot Community

FARM	pH H_2O	pH HCl	CEC, MEQ/L	N, %	P, ppm	Al, ppm
Baghan	5.40	4.32	7.60	0.26	0.63	0.15
Munoh	5.44	4.23	10.78	0.56	0.69	0.00
Gyindong	5.56	4.39	20.67	0.96	2.50	0.96
Tah	5.28	4.24	43.12	1.12	1.17	2.12
Tangyie	5.26	4.30	13.68	0.47	0.69	0.00

Source: Authors.

TABLE 5.3: Scale Used for the Evaluation of the Pasture Degradation Status in Paddocks

LEVEL OF DEGRADATION	EDIBLE SPECIES, %	WEEDS, %	BARE SOIL OR ROCKS, %	EROSION
None	>80	<5	None	None
Slight	50–80	5–15	Small spaces	None
Moderate	20–50	15–40	Isolated spots	None
Severe	<20	40–60	Isolated spots	Sheet erosion
Very Severe	<20	>60	Uniformly distributed	Gullies

Source: Betancourt *et al.* 2007.

TABLE 5.4: Botanical Composition (Percent) of the Paddocks Chosen for Intervention in the Five Pilot Farms

FARM	EDIBLE GRASSES	LEGUMES	BROAD-LEAF WEEDS	NARROW-LEAF WEEDS	FERNS	BARE SOIL
Baghan	16.5	1.2	7.5	12.6	0.0	62.2
Munoh	27.5	3.3	12.7	15.2	2.1	39.3
Gyindong	37.7	2.4	12.8	7.2	6.3	33.6
Tah	26.6	6.9	17.7	3.1	6.9	38.8
Tangyie	47.6	0.5	7.3	3.3	4.1	37.2
Mean	**31.2**	**2.9**	**11.6**	**8.3**	**3.9**	**42.2**

Source: Authors.

nonidentified woody legumes. Some *Stylosanthes* sp. was also found on Tah Farm, but the farm operator declared he introduced it some time ago.

Weeds (broad leaf, narrow leaf, and ferns) covered more than 23.8 percent on average, ranging from 14.7 to 30.0 percent (table 5.4). Two of the farms presented a higher proportion of narrow-leaf weeds (Baghan and Munoh farms) than broad-leaf weeds, whereas the opposite occurred on the other three farms. The basal cover of ferns was not high (3.9 percent on average) in the first evaluation, which was carried out by the end of the dry season, probably because many mature plants were affected by fire, and most ferns were just emerging (figure 5.3). However, their cover increased significantly after the rains started, as they have strong rhizomes that are not affected by fire (figure 5.4) (Pezo and Azah 2010d). The dominant species of ferns, known locally as *"iwheungh,"* was not seen by project staff, but the most common fern seems to be the well-known *Pteridium aquilinum*, which is poisonous to animals. The presence of blood in urine is said to be characteristic of animals poisoned by this fern; some locals affirmed this while others did not, but all agreed that animals do not regularly eat this species, except accidentally when availability of other edible forages is low.

Iron grass (*Sporobolus indicus*) was considered a weed even though some Cameroonian colleagues consider this species edible because it is palatable during the rainy season, when it is in a vegetative stage. It was considered a weed in this study because its nutritional quality declines drastically late in the rainy season and even more so in the dry season and it is rejected by animals (Padilla and Curbelo 2004). Iron grass was the most frequently found narrow-leaf weed in

FIGURE 5.3: Evaluating Pasture Degradation in the Dry Season

Source: Authors.

FIGURE 5.4: Evaluating Pasture Degradation in the Rainy Season

Source: Authors.

the paddocks, but spear grass (*Imperata cylindrica*) was also common in some pastures. These species appear to be fire tolerant, as regrowth of both was found in pastures that were burnt at the end of the dry season. Also, both are profuse seed producers. All these factors make these species highly invasive. Selective weeding to control these weeds as well as others, the oversowing of palatable and more competitive forage species, and improved grazing management strategies such as rotational grazing and the adjustment of stocking rate to forage availability were implemented to rehabilitate degraded pasture lands.

The presence of bare soil, stones, and rocks in the pastures varied between 33.6 and 62.2 percent (table 5.5). This is very high for pastures, and the former makes soil more prone to erosion. However, it should be emphasized that the evaluation was made at the end of the dry season, when most herbaceous species are senescent, and in some areas, the pastures were burnt. As expected, the vegetation cover increased once the rains became more uniform, but soil losses were also high in the early rainy season due to the high rainfall intensity and the location of most pastures on steep, sloping land. Even though measurements of soil erosion were not made, it was assumed that the loss of nutrients with the early rains was significant, as a high proportion of the surface soil organic matter (litter and standing aerial biomass) was burnt at the end of the dry season. In fact, this management practice and overgrazing were identified as the main causes of the high weed infestation observed in most pastures in the Gutah Hills (Pezo and Azah 2010d).

Based on the vegetation and soil cover data, estimates of potential soil erosion, and the scale proposed by Betancourt *et al.* (2007), it was estimated that three of the pastures were moderately degraded, one was slightly degraded, and one was severely degraded (table 5.5).

However, when the evaluation was made based on the appearance of pasture conditions in different sectors of the same paddock, there was a clear gradient of degradation from slight to severe (table 5.6) depending on the management imposed in the different sectors, as well as on the slope of the paddock sections. For example, on pastures evaluated at the community farm (Gyindong), the stratum located in the flat and slightly undulating area (Gyindong 2) had a higher proportion of edible grasses (mostly kikuyu and star grasses) and no clear signs of soil erosion. The presence of both species could be considered an indicator of higher soil fertility levels, which is understandable because animals were kept in the area at night, contributing to a higher accumulation of manure. The other two strata (Gyindong 1 and 3) had similar

TABLE 5.5: Level of Pasture Degradation in the Paddocks before Intervention with Silvopastoral Options in Five Pilot Farms in Tugi Village and the Tuochup Quarter

FARM	EDIBLE SPECIES,[a] %	WEEDS, %	BARE SOIL OR ROCKS, %	EROSION	LEVEL OF DEGRADATION
Baghan	17.7	20.1	62.2	Sheet	Severe
Munoh	30.8	30.0	39.3	Sheet	Moderate
Gyindong	40.1	26.3	33.6	Sheet	Moderate
Tah	33.5	27.7	38.8	Sheet	Moderate
Tangyie	48.1	14.7	37.2	Sheet	Slight
Mean	**34.0**	**23.8**	**42.2**	**Sheet**	**Moderate**

[a]The assumption is that all species classified as legumes are edible.
Source: Authors.

TABLE 5.6: Level of Degradation within the Paddock Before Intervention with Silvopastoral Options at Gyindong Community Farm in Tugi Village

STRATUM	EDIBLE SPECIES,[a] %	WEEDS, %	BARE SOIL OR ROCKS, %	EROSION	LEVEL OF DEGRADATION
Gyindong 1	28.5	32.1	39.4	Sheet	Moderate
Gyindong 2	69.3	7.4	23.3	None	Slight
Gyindong 3	18.9	42.1	39.0	Sheet	Severe

[a]The assumption is that all species classified as legumes are edible.
Source: Authors.

topography, but the latter had the highest presence of weeds and the lowest presence of edible species. Based on those results, it was suggested that the silvopastoral interventions that involve grazing should be established in strata 1 and 2, and that stratum 3 should be left for the implementation of some agro-forestry options, including fodder banks.

Given the short duration of the project and the slow pasture rehabilitation process, TUSIP technical staff were not able to get detailed estimates of changes in forage availability and quality or on the performance of the native cattle grazing in the degraded and recovered pasturelands. However, after visiting the Acha-Tugi Cattle Market and talking to farmers, traders, and technicians, it was clear that animals usually reach market weight at six to seven years and that heifers have the first parturition at four to five years. These figures appear to show that the poor animal productivity in the Gutah Hills is associated with the degraded pastures. However, to assess the potential economic impact of the rehabilitation of degraded pastures as proposed by TUSIP, data obtained by CATIE in Central America showed that slightly degraded pastures result in a 13-percent reduction in live weight gain per animal compared to nondegraded pastures and reductions of 24 and 30 percent for moderately and severely degraded pastures, respectively. Also, the stocking rate reduces from a potential of 2.0 animal unit (AU) per ha for nondegraded pastures to 1.7, 1.3, and 1.0 AU per ha in the case of slightly, moderately, and severely degraded pastures, respectively. After valuing those changes, it was estimated that farmers' income is reduced by USD 169, 343, and 440 per ha per year when comparing slightly, moderately, and severely degraded pastures versus nondegraded pastures (Betancourt *et al.* 2007).

Based on the results obtained in the pasture degradation assessments and the results obtained in the soil samples taken in January 2010, the project staff defined the strategies to be applied in each farm for the renovation or rehabilitation of degraded pastures. In general terms, the strategies included the following measures—intensive weed control, oversowing of grasses and legumes, and fencing to initially protect the land from defoliation by stranded animals, which would also later aid implementation of a rotational grazing scheme.

5.4 REHABILITATION OF DEGRADED PASTURES

In pastures with less than 40 percent edible species—as found in almost all Tugi pastures evaluated—renovation strategies, including using chemical herbicides to kill the standing vegetation and ploughing and harrowing for full soil

preparation before planting new seeds, are usually recommended (Días-Filho 2007). However, considering the topography of the grazing areas, the interest in reducing costs and minimizing soil disturbance, the lack of machinery for land preparation, and the fact that project interventions were implemented when the rains were strong, rehabilitation strategies based on restoration ecology mechanisms were selected. It was recognized that this would require spending more effort reducing the competition exerted by the existing nondesirable species and from those emerging from seed banks already existing in those pastures.

The vegetation analysis based on basal cover carried out in March 2010 did not document the severity of the presence and invasiveness of the bracken fern (*Pteridium* sp.) (figure 5.5). In the sampling done in March 2010, the presence of bracken fern varied between almost 0 percent at Baghan Farm and 12 percent in the most infested strata at Gyindong Community Farm. However, after seeing the infestation in other pasture areas in the region and based on knowledge of the resilience of the weed, special efforts were made to control it more so than for other weeds. The invasive potential of the bracken fern is well known, especially after pastures are burnt and the rains start, due to the very strong and profuse rhizomes this species has and the open spaces left after burning the standing vegetation. In fact, after the first clearing of weeds, the bracken fern became the most dominant weed. However, the bracken fern was allowed to produce new young fronds after the first hand weeding, and a second weeding was applied after the new fronds emerged. A third light hand weeding was required in some of the pastures before oversowing the grass and legume seeds. Records were kept on the labor required for all of these practices, as it is one of the most relevant cost items in the rehabilitation of degraded pastures, although the cost of labor in Cameroon is not as high as in other countries in the region.

FIGURE 5.5: The Bracken Fern, a Very Potent Invasive Weed

Source: Authors.

It is well known that for the effective control of bracken fern, it is better to use an integrated approach of mechanical weed control followed by application of a herbicide to the young shoots with at least one expanded frond (figure 5.6). Glyphosate, fluroxypyr, and metsulfuron methyl are recognized as the most effective herbicides for controlling bracken fern. Glyphosate was not used because it kills all standing biomass, and some desirable grass and legumes were already present in the paddocks. The other two herbicides have more specificity of action but were not available in the closest market (Bamenda). Metsulfuron methyl was obtained from a provider of agricultural inputs in Douala (more than seven hours away from Tugi); it was tested in late October 2010 with positive results, at least on a small scale. However, it will be necessary to compare on a larger scale the bioeconomic feasibility of mechanical weeding versus the integrated control approach combining mechanical and chemical control.

FIGURE 5.6: Chemical Control of the Bracken Fern

Source: Authors.

As a result of weed control practices and exclusion of animals from the paddocks under rehabilitation, important changes occurred in their botanical composition. They were also favored by the rains that fell during the early rainy season. The comparison between assessments made in March and June 2010 (table 5.7) showed an increase in the percentage of edible grasses and legumes and a reduction in the area of bare soil. However, the percentage of broad-leaf weeds, especially the bracken fern, also increased. This observation confirms how important it is to emphasize weed control as part of the whole pasture rehabilitation strategy; without it, the fern and other weeds may dominate the pastures, precluding planted grasses from developing properly.

Different options were recommended for enriching the contribution of edible forage species in the pastures under rehabilitation. Oversowing of grasses and legumes and applying minimum tillage strategies were the first options. For that purpose, it was suggested that immediately after broadcasting the seeds of oversown forages, grazing animals should be introduced at a high instantaneous stocking rate (many animals for a very short period, such as less than two days), to defoliate the grasses and legumes grown during the exclusion period that could interfere with the sun needed by the younger plants emerging after planting. The decision to take animals out of the pasture was defined by the height of residue, such as 5 to 10 cm in the case of iron grass. It was expected that the trampling exerted by grazing animals would also help introduce the broadcasted seeds into the soil bed, promoting better contact between seeds and soil and preventing seeds from being washed out by rain. In those paddocks where direct oversowing was applied, it was recommended that grasses and legumes be planted, preferably in lines to facilitate weeding. Based on the germination rate observed in the seeds purchased, the recommended dosage per hectare was 4 kg of legume seeds (using 2 kg of *Stylosanthes guianensis* plus 2 kg of *Desmodium uncinatum*) and 10 kg of *Brachiaria ruziziensis*.

Another option recommended in the case of *Brachiaria ruziziensis,* which presented a very low germination rate (less than 5 percent), was to prepare a sort of nursery using well-prepared seed beds in which seeds were planted at a very high sowing rate (equivalent to 80 to 100 kg/ha). Those seed beds should contain a mixture or either manure or sand (about one-third) and soil (about two-thirds) to facilitate germination and extraction of plants for transplanting. It was also recommended that seed beds have enough moisture at all times and to apply a complete formula (high in P), at a rate of approximately 25 kg/ha, when the seedlings of grasses and legumes reach 5 to 10 cm. This option was initially implemented at Baghan Farm with good success, but fertilizer could not be applied because it was not available in the closest market.

The third option, and probably the most effective, was the use of vegetative material collected in some of the paddocks and transplanted to the paddocks under rehabilitation. Tangyie Farm was the first to use this strategy for *Brachiaria ruziziensis*; in others (Tah and Gyindong), a similar technique was applied for kikuyu grass (*Pennisetum clandestinum*). Moreover, in the spaces left uncovered after taking the grass, seeds of the two herbaceous legumes mentioned above were sown.

The introduction of grazing animals was delayed until the end of the rainy season when enough biomass was available, and some of the species had already flowered and produced seeds, which in turn helped enrich the soil seed banks. This strategy was used at Munoh, Tah, and Tangyie Farms, and animals were allowed to graze down the paddocks when the dry season started to reduce the amount of dry biomass available (which could function as fuel if fires

TABLE 5.7: Changes in Vegetation Cover Due to Management in the Grazing Areas of Two Pilot Farms

FARM/DATE OF EVALUATION	EDIBLE GRASSES	LEGUMES	NARROW-LEAF WEEDS	BROAD-LEAF WEEDS	BRACKEN FERN	BARE SOIL
BAGHAN FARM						
March 2010	16.5	1.2	12.6	7.5	0.0	62.2
June 2010	31.3	7.9	15.9	16.4	2.1	26.4
TAH FARM						
March 2010	26.6	6.9	3.1	17.7	6.9	38.8
June 2010	29.5	17.9	5.6	22.1	13.4	11.5

Source: Authors.

accidentally started). The seed banks started to germinate with the early rains of 2011, and coverage of valuable forage species increased significantly in all rehabilitated paddocks.

5.5 FENCING AS THE BASIS FOR ESTABLISHING ROTATIONAL GRAZING

Extensive pasture management with no fences is a common practice in the Gutah Hills, resulting in poor animal productivity and low income, degradation of pasture lands and natural resources, and frequent conflicts between grazers and farmers due to the destruction of crops by stranded animals. To protect the areas managed under crops, farmers usually build simple fences made of raffia bamboo and sticks and sometimes plant sisal and other shrubs in between, but those fences tend to be temporary and do not prevent animals from going into the crop land.

Fencing was one of the technology innovations promoted by TUSIP; details of how they were built are described in a technical bulletin prepared by Pezo and Azah (figures 5.7 and 5.8) (2010c). A summary of the costs per 100 m of dead fence using barbed wire is shown in table 5.8. The costs could be reduced to about USD 200 if four lines of barbed wire instead of five are installed (that is, if sheep are not managed close by). Costs could also be reduced if the farmer produced the posts on his own farm and if the work was done using family labor, but even then, the cost would be about USD 140 to 160 per 100 m.

Although the main purpose of fencing in TUSIP pilot farms was implementation of a well-planned rotational grazing management, which is absent in traditional livestock systems in the Gutah Hills, the practice has other purposes as well, oriented either to improving animal productivity and pasture management or to preventing farmer-grazer conflicts. Some additional purposes for building fences in pastures are the following:

- To reserve certain areas for the dry season, either as standing hay for direct grazing or for the preparation of conserved forages (such as hay or silage)
- To prevent animals from going into those pastures that were recently fertilized or treated with pesticides
- To prevent animals from grazing in areas reserved temporarily for seed production, either for natural reseeding or harvest of seeds
- To protect either crops or cut-and-carry forage banks from damage by straying animals.

FIGURE 5.7: Tensioning Barbed Wire and Nailing a Dead Fence

Source: Authors.

FIGURE 5.8: Constructing a Fence Gate

Source: Authors.

TABLE 5.8: Costs of Installing 100 m of Permanent Barbed Wire Fence in Tugi Village, NWR Cameroon

ITEM	USD
1 roll of large galvanized wire (200 m long)	80.00[1]
4 rolls of small galvanized wire (75 m long) @ FCFA 6,500 each	56.00
41 poles 4 cm x 4 cm x 2 m @ FCFA 450 each	36.90
Digging and fitting 41 poles @ FCFA 350 each	28.70
Carrying 41 poles @ FCFA 75 each	6.15
Nails (1 kg)	2.00
Labor (2 workers @ FCFA 1,500 for five lines)	6.00
Total	215.75

[1] 1 USD = FCFA 500.
Source: Pezo and Azah 2010b.

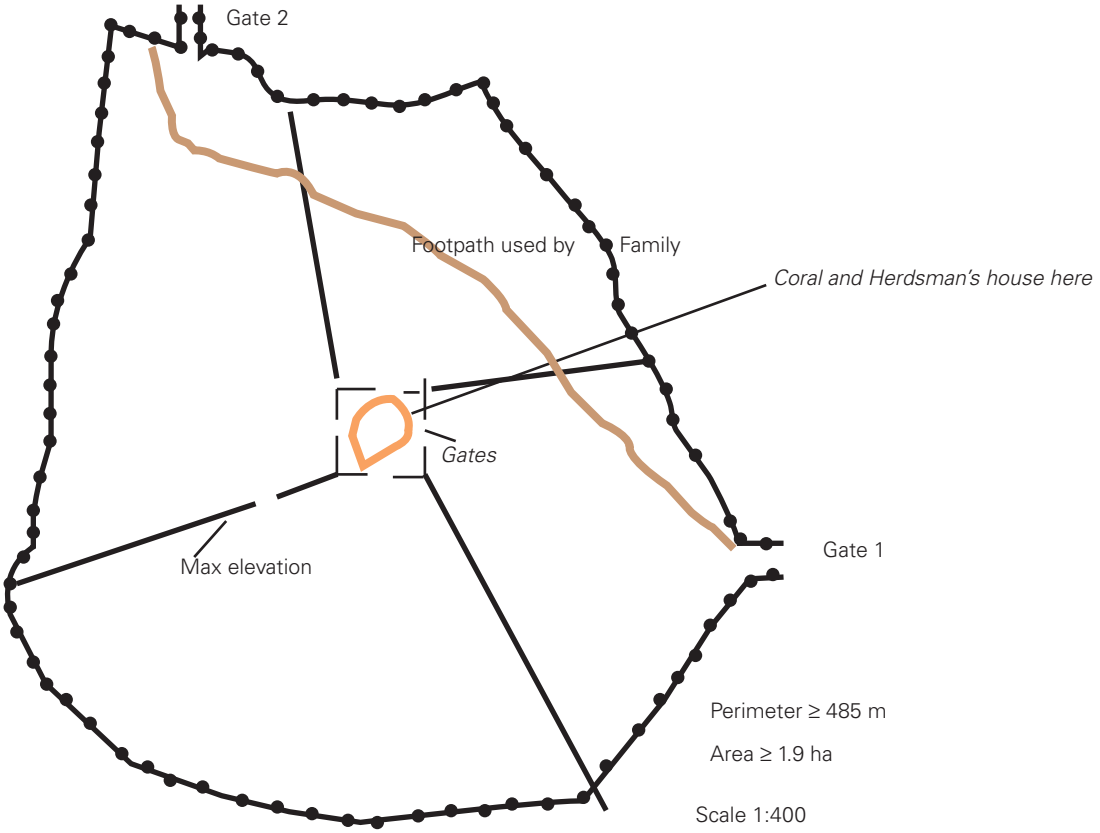
The size of the grazing area chosen for implementing the silvopastoral interventions defined the number of paddocks to be installed. In the case of Baghan and Tah Farms, two paddocks were established because the areas assigned were only 1.1 and 0.9 ha, respectively; on Tangyie Farm with 2.0 ha of grazing area, the pasture was divided into four paddocks (figure 5.9). On the Munoh Farm, with 4.4 ha, five paddocks were established (figure 5.10).

On the Gyindong Community Farm, ten paddocks were installed, four of them in front of the herdsman's house where there was a good cover (approximately 98 percent) of kikuyu grass (*Pennisetum clandestinum*). It was only necessary to build the fences there. In contrast, in paddocks 5, 6, 7, and 8, a total area of about 6.5 ha, it was necessary to oversow 250 kg of *Brachiaria* seeds because the area was slightly degraded at the start of the 2011 rainy season with a high cover of *Sporobolus indicus* and other weeds.[1] The distribution of those paddocks and the corresponding fencing are shown in figure 5.11. Additional fencing might be needed before bringing the animals to those paddocks because there are some cattle routes around the bushes that have been taken as the live fences for the paddocks in the lower side of paddock 8. Moreover, as the area to the left side of paddocks 5 to 8 has a steep slope, it was divided into two paddocks (9 and 10), but trees will be established there, instead of using the area for grazing.

5.6 ESTABLISHMENT OF GRASS/LEGUME FODDER BANKS

The few fodder banks made of Guatemala grass (*Tripsacum laxum*) found in Tugi are mostly to be used during the dry season, but many of them had not been used for more than one year when the project started. As a consequence, most grasses present in the fodder banks were too old and the nutritive value was very poor. The technology innovation proposed by the project involved introduction of a woody

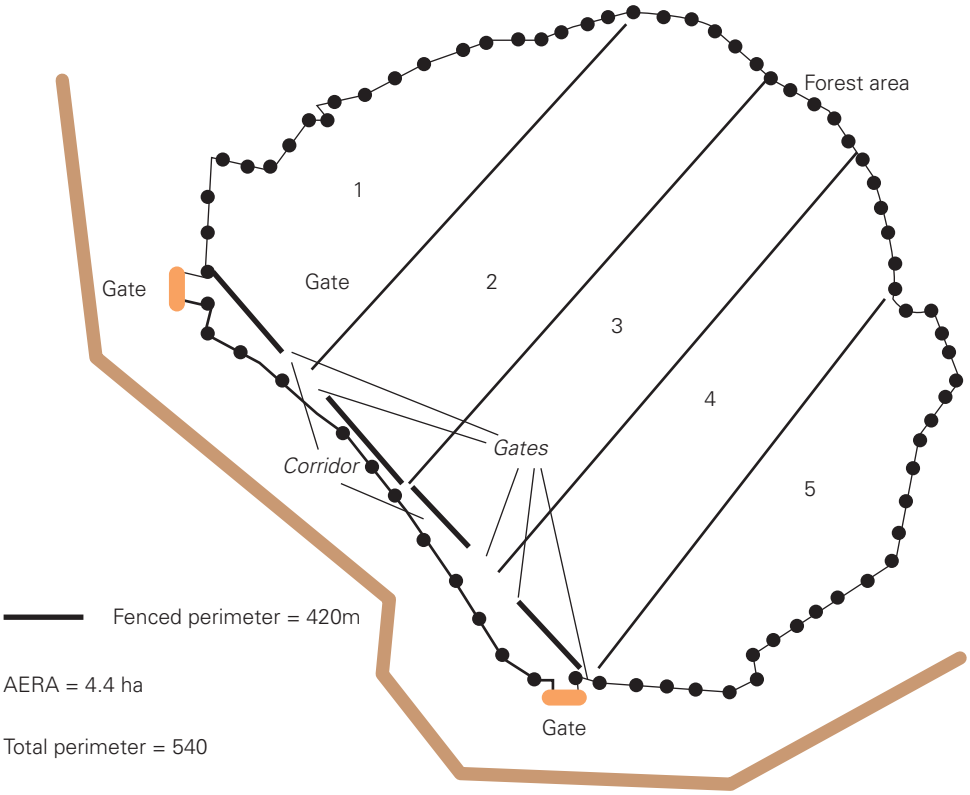
FIGURE 5.9: Fencing and Paddocks Arrangement at Tangyie Farm



Source: Authors: Pezo and Azah 2010b.

1 Identified as Gyindong 2 in Table 5.6.

FIGURE 5.10: Internal Division of Paddocks in the Grazing Area at Munoh Farm



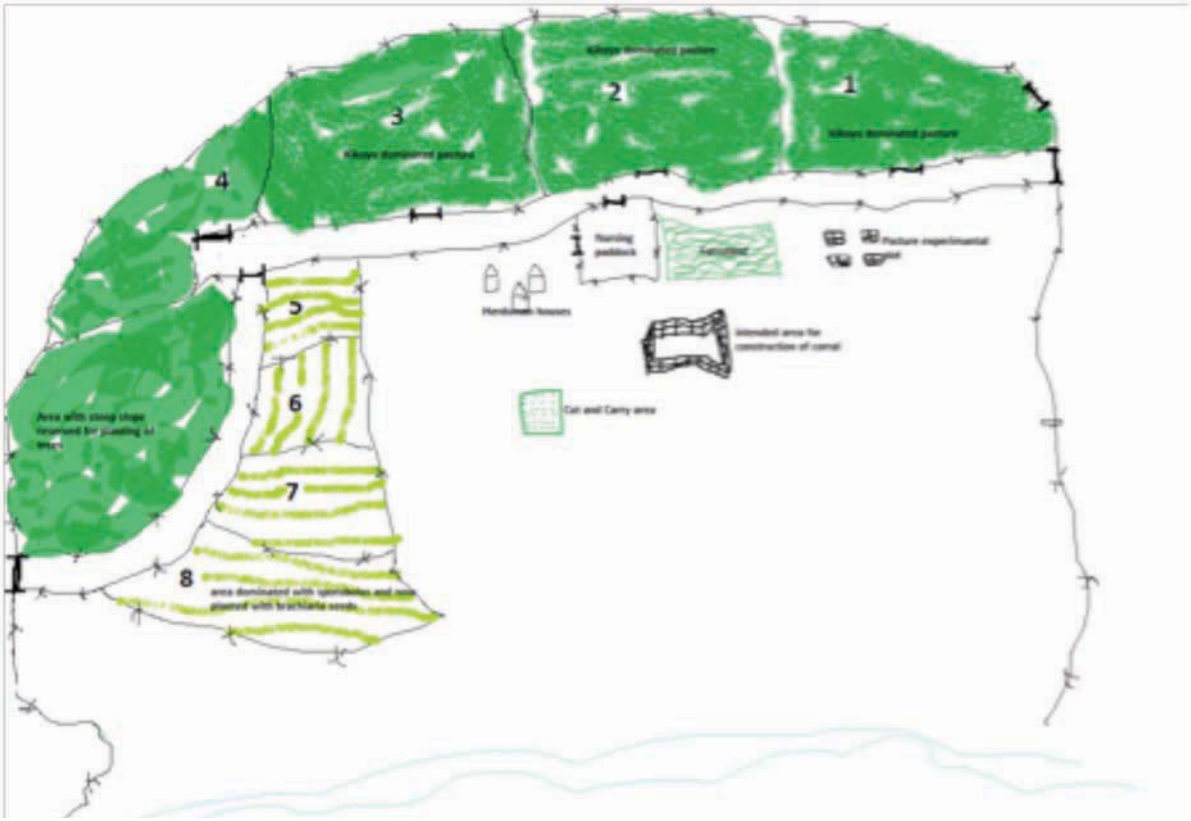
Source: Authors: Pezo and Azah 2010b.

legume with a twofold purpose—to increase the protein content of the cut-and-carry forage and to improve soil fertility through nitrogen fixation and transfer and enhancement of the nutrient cycling process. Also, as the proposed system was semi-zero grazing for at least part of the herd, it was proposed that the fodder banks play an important role in a year-round feeding strategy, offering cut-and-carry forage not only fresh during the dry season, but also harvested during the rainy season, either to complement grazing or for conservation as silage for the dry season.

The fodder banks established at the four family pilot farms in 2010 were composed of Guatemala grass and a woody legume (*Acacia angustissima*); on Gyindong Community Farm, established at the start of the rainy season of 2011, *Acacia* was replaced by *Leucaena leucocephala*. The proportion of lines of Guatemala grass and *Acacia* could vary, but the fodder banks established in the four pilot farms have two lines of grass and one line of the legume. Although some farmers might prefer to plant a double line of the legume in between the rows of grass, in this case a single line was chosen. The distance between rows of either of the two forages was 1.5 m, but the distance between planting positions was 0.75 m for grass and 0.5 m for the legume. One cutting of Guatemala grass with three nodes was planted in each position; for the legume, three to five seeds were planted. Finally, it was proposed that only two plants of *Acacia* per position should be used. The small number of *Acacia* seeds per position was used because they have a high germination rate (87 percent). In all cases, Guatemala grass cuttings were prepared the day before planting, and it was accidentally discovered that they could be maintained in the shade for more than two days, considering that the weather is mild in Tugi. The legume seeds were scarified by soaking them in water for 12 to 24 hours until the seeds swelled.

As all areas chosen for planting the fodder bank had steep slopes and a very high weed infestation (mostly of bracken fern), up to two hand weedings were needed before planting. The rows were placed perpendicular to the slope, planting the grass and the legume in hedgerows to prevent soil erosion. The labor was performed by the farm operator, supported by project staff on the Baghan Farm, and by women's groups on the rest of the pilot farms. The

FIGURE 5.11: Internal Divisions for Paddocks at the Gyindong Community Farm



Source: Authors; Pezo and Azah 2010b.

planting work done at Munoh Farm was not as uniform as expected because the group assisting was too big (which complicated the managing of the planting) and because it was the first time project staff had worked with women's groups.

Some of the fodder banks were supposed to be ready for use in the 2010–2011 dry season, but the results on all pilot farms were not as successful as hoped; many plants had to be replaced. Three key factors explain the failures: (1) high weed infestation that was not properly controlled, (2) the sloping land chosen by farm operators to establish the fodder banks had very poor soil fertility and neither organic nor chemical fertilizers were applied, and (3) when plants were producing the first leaves, sheep broke into some of the fodder banks and defoliated them severely, resulting in plant deaths. In spite of this, many people in Tugi Village started establishing fodder banks in small areas to feed their animals based on participatory learning sessions in which project staff shared the lessons learned. At the time this report was being written, project staff were applying a complete fertilizer formula (14-24-14) using a ringing method.

If the technology is going to be applied on other farms or other areas on the pilot farms, Guatemala grass could be replaced by Napier grass (*Pennisetum purpureum*) or guinea grass (*Panicum maximum*), which are available in the country. These were not tested because the genotypes found in the area did not have better attributes than Guatemala grass, the uniformity of the planting materials could not be assured, and its collection from the roadsides represented too much effort for the project team (time was always a limiting factor). The legume component (*Acacia angustissima*) could also be replaced by other legume woody perennials. TUSIP purchased small amounts of *Calliandra calothyrsus*, *Leucaena leucocephala*, and *Sesbania sesban* and received small quantities of *Leucaena* spp. and *Gliricidia sepium* seeds from the International Livestock Research Institute (ILRI); any of those could be incorporated in the fodder banks.

5.7 INVESTMENT IN REHABILITATING GRAZING AREAS AND PLANTING THE FODDER BANKS

Information on the quantity and costs of labor and materials used in the rehabilitation of degraded pastures, planting of

cut-and-carry forages, and fencing was recorded on all pilot farms. Table 5.9 shows the investment in the five pilot farms; however, it should be noted the Community Farm's fodder bank at Gyindong was established at the start of the 2011 rainy season, so there may be additional costs for weeding in the months that followed that are not captured in the table (figures 5.12 and 5.13).

The total investment in fencing and weeding is presented for each farm (table 5.9). It does not make sense to compare the fencing costs per unit area in each farm because the nature of the divisions varied according to the paddock design; however, it is relevant to compare the estimates of weeding costs per hectare on the different farms; these varied between USD 53 and 200. This variation could be explained in terms of the level of weed infestation and the aggressiveness of the bracken fern after cutting, but the values were also influenced by the contribution of family labor on some farms (not included in the cost estimates). Economies of scale could also be a source of variation considering that higher costs were observed for the smallest areas planted or rehabilitated.

5.8 BUILDING MULTISTRATA LIVE FENCES

The establishment of multistrata live fences as part of a grazing management strategy was a new technology introduced by TUSIP, although some live fences around the housing compounds and corrals, and in some cases protecting croplands, were already established in the village. The existing live fences were made mostly of cypress (*Cupressus* sp.), tree marigold (*Tithonia diversifolia*), sisal (*Agave* spp.), *Erythrina* spp., and other nonidentified local shrubs. Although project staff suggested increasing the use of *Tithonia diversifolia* in

TABLE 5.9: Area and Perimeter Fenced, and Investment in the Five TUSIP Pilot Farms, Considering the Grazing and Fodder Bank Areas Established

FARM	GRAZING		CUT-AND-CARRY		INVESTMENT (USD)	
	AREA, ha	PERIMETER, m	AREA, ha	PERIMETER, m	FENCING	WEEDING USD/ha
Baghan	1.1	280	0.4	250	1,145	80
Munoh	4.4	420	0.5	320	1,598	328
Gyindong	32	790	1	400	2,105	650
Tah	0.9	300	0.5	310	1,318	180
Tangyie	2	490	0.5	320	1,750	210
Total	**40**	**2,280**	**3**	**1,201**	**7,916**	—

Source: Authors.

FIGURE 5.12: Preparing Guatemala Grass Cuttings

Source: Authors.

FIGURE 5.13: Planting a Guatemala Grass Plus Acacia Fodder Bank

Source: Authors.

the live fences due to its value as a fodder source, farmers were not interested because it tends to expand and widen the live fence in a way that significantly reduces the grazing area, which is especially confining for small paddocks.

TUSIP proposed using several species of different heights and shapes (multistrata) and potential uses (multipurpose) for the live fences, but little was done in the period reported. Some farm operators planted locally available species (such as sisal), and project staff introduced *Acacia angustissima* in the fences of some of the forage banks (but not in the grazing areas, as it is an edible species that could be damaged by grazing animals). However, to enrich those fences, new tree germplasm was obtained by establishing collaborative work with the World Agro-forestry Centre (ICRAF). Also, it was suggested that *Erythrina* spp. stakes be gotten from the Presbyterian Rural Training Center (PRTC)–Fonta and Tangyie Farm to enrich the fences with this valuable fodder tree. Additional nursery work needs to be implemented with the seeds of *Acacia angustissima* and *Calliandra calothyrsus* already acquired by TUSIP, as well as with timber and fruit species obtained through ICRAF, before planting those in the fences. It is foreseen that such enrichment could take place in 2012 if the size of the trees allows for it.

Chapter 6: EVALUATION OF FORAGE GERMPLASM

The availability of good-quality forage germplasm was identified as one of the limitations for the implementation of more diverse options for the rehabilitation of degraded pasturelands, the establishment of fodder banks and multistrata live fences, and diversification of the crop-livestock systems in Tugi. Seeds of only one grass species (*Brachiaria ruziziensis*), of a few woody legumes (*Acacia angustissima, Sesbania sesban, Leucaena leucocephala, Calliandra calothyrsus, Cajanus cajan,* and *Tephrosia vogelii*) and two herbaceous legumes (*Desmodium uncinatum* var. Silverleaf and *Stylosanthes guianensis*) were purchased from a farmers' group trained by ICRAF and operating in Bambui (NWR). The first step was to determine the germination rate using two options, soil and paper towel. The values obtained were extremely low (less than 5 percent) for the grass; intermediate (30 to 47 percent) for *Leucaena*, *Cajanus*, and *Desmodium*; and high (more than 85 percent) for *Sesbania*, *Acacia,* and *Tephrosia* (figure 6.1). Furthermore, the germination rate of most of the species declined sharply with time probably because the conditions in the Tugi project office were not appropriate for seed conservation.

FIGURE 6.1: Evaluation of Forage Seed Germination Rate

Source: Authors.

Contacts were established with ICRAF and ILRI to get additional germplasm. The former provided some fruit and medicinal species, whereas the latter provided a diversity of grasses and forage legumes, which were the best bets agreed upon by the project staff and ILRI experts considering the prevalent conditions in Tugi. The species/cultivars included in the set offered by ILRI are listed in table 6.1; however, ILRI was asked to send no more than four accessions of *Gliricidia sepium*. There were problems delivering the seeds to TUSIP, and it took almost two months before they arrived in Bamenda. Consequently, only three plants of Napier grass

TABLE 6.1: Forage Species/Accessions Provided by ILRI for Testing under Tugi Village Conditions

GRASSES	WOODY LEGUMES	HERBACEOUS LEGUMES
Brachiaria brizantha cv. Marandú	*Gliricidia sepium* 14504, 14507	*Desmodium intortum* 104 (cv. Greenleaf)
Brachiaria decumbens 10871	*Gliricidia sepium* ILG 66, 67, 68, 69, 70	*Desmodium uncinatum* 6765 (cv. Silverleaf)
Panicum maximum 11	*Leucaena diversifolia* 14193	*Stylosanthes guianensis* 4 (cv. Cook)
Panicum maximum 6946	*Leucaena leucocephala* 14198	*Stylosanthes guianensis* 73 (cv. Graham)
Pennisetum clandestinum 6574	*Leucaena leucocephala* 70 (cv. Cunningham)	*Stylosanthes guianensis* 164 (var. Pucallpa)
Pennisetum purpureum 16786	*Leucaena pallida* 14203	*Trifolium repens* 6896
Pennisetum purpureum 16835		*Arachis pintoi* (cv. Amarillo)
Pennisetum purpureum 14984		

Source: Authors; Pezo and Azah 2010b.

(*Pennisetum purpureum*) Accession 16835 survived, as the rest of the stem cuttings were dry when they arrived.

All seeds arrived late in the rainy season, so planting was postponed until the next rainy season. The exception was for the woody legumes, which were planted in bags, watered regularly, and kept in the nursery. Also, part of the *Arachis pintoi* cv. Amarillo lot was planted in a seed bed (figure 6.2). None of the *Gliricidia sepium* seeds germinated, even though they were planted twice, with and without scarification treatment; germination was high in the case of the different genotypes of *Leucaena* spp. (table 6.2). The collection was enriched with some additional grasses and legumes carried by the field research assistant after he completed his training in Costa Rica.

The plan was to test all grasses and legumes in the field under two contrasting conditions, at Gyindong Community Farm (approximately 1,500 MASL) and Tah Farm (approximately 2,000 MASL). The design and methods for evaluation were elaborated during the training of the field research assistant in Costa Rica, taking as a basis the methodologies proposed by CIAT for the International Network for the Evaluation of Tropical Pastures (RIEPT) (Toledo and Schultze-Kraft 1982). The full set of seeds was planted in the Community Farm at the beginning of the 2011 rainy season.

FIGURE 6.2: Planting Fodder Tree Seeds in the Nursery

Source: Authors.

TABLE 6.2: Germination Rate for Seeds of Woody Legumes Received from ILRI and Planted at the Nursery in Tugi Village

SPECIES/ACCESSIONS	SEEDS PLANTED	SEEDS GERMINATED	GERMINATION RATE, %
Leucaena pallida 14203	48	48	100
L. diversifolia	48	40	84
*L. leucocephala**	48	48	100
L. leucocephala 70	48	38	80
Gliricidia sepium 14503	48	0	0
G. sepium 14507	48	0	0
G. sepium 14504	48	0	0

Source: Authors; Pezo and Azah 2010b.

Chapter 7: PROPAGATION AND IMPROVEMENT OF NONFODDER TREES

Diversification of the tree component with fruit and medicinal trees was another strategy promoted by TUSIP. For this, links were established with staff of the ICRAF based in Bamenda. Under ICRAF guidance, project staff built a simple tree nursery facility in Tugi-Tugi. The structure measured 10 × 6 m and was oriented in a west-to-east direction. Inside, polyethylene bags with some of the fruit, medicinal, and spice tree species were placed, as well as a few of the fodder trees received from ILRI (figure 7.1). Also, ICRAF guided installation of a propagator for multiplying some of the medicinal plants (figure 7.2). Outside the covered area, some seed beds were installed for local kola nut (*Kola niticia*) and avocado (*Persea americana*) seeds and forage groundnuts (*Arachis pintoi*).

Among the non fodder trees ICRAF brought for propagation were kola nuts (*Kola niticia* or *K. vera, Schum*), njansang (*Ricinodendron* spp.), and African plum or pygeum (*Prunus africana*). Kola nut is a native species whose fruits are traditionally consumed by the village population. Kola nut is rich in caffeine and serves as a valuable nerve and heart tonic. Njansang is a very popular spice in Cameroonian cuisine, and the kernels are known to help reduce cholesterol. The African plum's bark is used to treat bladder and prostatic hyperplasia; it is in danger of extinction due to overuse. All three adapt very well to the conditions of Tugi and have the potential to be incorporated into the agro-forestry options promoted by TUSIP as a means of diversifying income.

FIGURE 7.1: General View of the Tree Nursery

Source: Authors.

FIGURE 7.2: Multiplying Fruit Trees in Polyethylene Bags

Source: Authors.

Chapter 8: OTHER INTERVENTIONS RELATED TO THE USE OF FODDER BANKS

8.1 DESIGN OF SEMI-ZERO GRAZING SYSTEMS

Intensification of livestock systems in Tugi, especially given the efficient use of the fodder banks and conserved forages, was planned to be implemented through the establishment of a semi-zero grazing system in which animals graze during the day and receive cut-and-carry forages and other supplements in pens during the late afternoon and night (figure 8.1). This practice is in principle was oriented to improve animal productivity through the increase in provision of forages besides the ones consumed during the grazing period, mineral supplementation, and the use of multinutrient blocks during the dry season; reduction in physical activity; and protection from low temperatures at night, which negatively affects the use of energy for production purposes (figure 8.2). An important additional benefit is that animals are kept close to the herdsman's house at night to prevent animal theft, which is a common problem in the Gutah Hills.

To implement these practices on the pilot farms, the participating farm operators started building corrals and a herdsman's house at their own expense. At the community farm, the construction was done with project funds although the labor was provided by the Tugi community. In all cases, TUSIP staff identified the location of the corrals and provided the designs for the pens, feeders, and watering facilities. To date, the corrals and herdsman's house at Munoh Farm have been completed, as has the herdsman's house at the community farm. Thus, the Munoh Farm is currently functioning as a quarantine facility for the animals purchased with TUSIP funds.

Estimates made by project staff suggested that the 0.5 ha of fodder bank already established on the family pilot farms would be enough to feed eight to ten fattening animals, which receive 15 kg of fresh forage per day; however, adjustments will be made by monitoring forage yield in the fodder bank. As problems were faced in the initial growth of the fodder banks, there was no information on the yield and quality of the forage produced in those areas to predict animal responses or the economic feasibility of the semi-zero grazing systems. Nevertheless, the research assistant was trained to use the LIFE-SIM simulation model (León-Velarde *et al.* 2006) once data are available. Based on previous experience elsewhere, it was recommended that the semi-zero grazing

FIGURE 8.1: Water Facilities in Semi-Zero Grazing Systems

Source: Authors.

FIGURE 8.2: Harvesting the Fodder Bank for Feeding Cattle

Source: Authors.

system start with very few animals, preferably fattening animals (starting at 200 kg BW), because this type of intensification will rarely be paid for by the cow-calf system or even by growing animals (from weaning up to 200 kg BW).

To sustain forage yields, the manure collected in the corrals has to be returned to the pastures. If a biogas system is eventually installed to use the manure produced in the corral, then the effluent should be used in the pasture as biofertilizer. Collecting the manure in the corral and transporting it to the farmland for fertilizing crops was not recommended because it would put the sustainability of the fodder bank at risk.

8.2 RAISING SHEEP AND GOATS IN ELEVATED PENS

Small ruminants are raised by some Meta families in Tugi, most of which have only two to five animals managed under a rotational grazing/browsing system whereby animals are tied with a rope in areas close to the family compound or the farmland; however, those sheep and goats often chew through the ropes and escape, damaging neighbors' cropland (figure 8.3). At night, most families bring the animals to the family compound and keep them in a rudimentary corral mostly at ground level. The manure is collected to apply on crops grown in the backyard.

An alternative is to keep small animals in elevated pens located in the family compound in a semi-zero grazing system. The animals would receive cut-and-carry forages obtained not only from fodder banks, but also from edible "weeds" collected and carried from the farmland at the end of the day. As crops are managed mostly by women, who also play an important role in managing small ruminants (Ndang *et al.* 2011), this activity was part of the Gender-Mainstreaming Component of TUSIP but was also considered an opportunity to integrate all family members.

Elevated pens are not new in Tugi Village, but the design currently used to hold pigs was modified to adjust to the needs of the women's groups working with small ruminants (figure 8.4). Most of the materials used were locally available, although for the first units built, zinc was used for the roof. Among the modifications promoted by TUSIP were construction of external feeders and a ramp and a barbed wire fence to delimit a small exercise area. CATIE'S technical advisor shared with project staff and farmers some designs of pens used for small ruminants in Central America and Southeast Asia, but the final decision on the pens' construction was made by staff in charge of the TUSIP Gender-Mainstreaming Component.

FIGURE 8.3: Goats Traditionally Managed with a Rope

Source: Authors.

FIGURE 8.4: Elevated Pens for Raising Sheep and Goats

Source: Authors.

Chapter 9: *EX ANTE* EVALUATION OF SILVOPASTORAL TECHNOLOGY INNOVATIONS

TUSIP rehabilitated degraded pastures and established fodder banks as described in previous sections. However, the duration of the project (22 months) was too short to get *ex post* estimates of animal responses, which are necessary to run economic analyses on the feasibility of the technology innovations. Based on the above, project staff used some timely field data on the growth in the degraded pastures (Control) and rehabilitated pastures, collected while the project operated. Several assumptions based on the literature and experience were made to run simulations with the LIFE-SIM model (León-Velarde *et al.* 2006), which gives estimates of the live weight gain, methane emissions, and excretion of manure and total nitrogen under different feeding strategy scenarios.

It is well known that in the subhumid tropics, pasture growth responds to rainfall distribution; in the highlands, growth could also be affected by low temperatures. Under the prevalent conditions in Tugi, low temperatures coincide with the dry season (November to February), so both limiting factors occur simultaneously. Table 9.1 shows the data used for simulations of three scenarios: (1) the current situation of degraded pastures managed with a herdsman; (2) pastures that have been rehabilitated applying strategies such as weed control, resting, fencing, replanting of edible grasses and legumes, and rotational grazing with controlled stocking rate; and (3) the same as (2), but in a semi-zero grazing system using a mixture of Guatemala grass and *Acacia angustissima* as supplementary fodder during the dry season (November to February) and the first stages of the rainy season (March) to prevent overgrazing during that period. The monthly variation in the amount of available pastures in the paddocks, as well as the energy (TDN) and protein content, are presented in table 9.1. The amount and quality (energy and protein contents) of the fodder offered during the most critical months of the year in the semi-zero grazing system are also included.

TABLE 9.1: Monthly Variation in Rainfall, Forage Availability and Quality, and the Amount and Quality of Fodder Offered for Three Feeding Strategies Based in Pastures in Tugi Village

	RAINFALL	DEGRADED PASTURES			REHABILITATED PASTURES			CUT-AND-CARRY FODDER		
MONTH		PASTURE AVAILABILITY, kg DM/ha	TDN,%	CP, %	PASTURE AVAILABILITY, kg DM/ha	TDN,%	CP, %	AMOUNT OFFERED, kg FRESH/DAY	TDN,%	CP, %
January	25	700	47	6.5	1700	48	7.5	20	58	10
February	50	600	45	6.0	1500	46	7.0	20	55	9
March	160	900	53	8.0	2500	60	12.3	15	58	10
April	205	1100	60	11.0	3000	65	14.0	0	—	—
May	225	1200	58	10.7	3600	63	13.7	0	—	—
June	325	1400	55	10.5	4000	61	13.5	0	—	—
July	410	1200	55	9.8	3500	61	13.5	0	—	—
August	380	1200	53	9.0	3500	59	12.5	0	—	—
September	500	1100	52	8.8	3200	57	12.0	0	—	—
October	290	1000	50	8.0	2800	55	10.5	0	—	—
November	95	900	49	7.1	2500	52	8.0	15	63	12
December	25	800	48	6.7	2000	51	7.5	15	60	10

Source: Authors.

9.1 BIOLOGICAL RESPONSES TO THE PROPOSED INTERVENTIONS

Rehabilitation of degraded pastures results in an increase in pasture availability, which in turn allows for a higher carrying capacity. This is improved even more when semi-zero grazing is applied because cut-and-carry forage partially replaces the pasture consumed under grazing. Based on those reasons, the stocking rate increased from 0.5 AU/ha, which is the common parameter in the degraded pastures that dominate the landscape in the Gutah Hills, to 1.75 AU/ha in the rehabilitated pastures, and up to 2.0 AU/ha when fodder is provided in a corral during the night (table 9.2).[2]

For all feeding strategies, the model was run assuming an initial BW of 200 kg, but it takes different periods of time to reach this weight when degraded or more productive rehabilitated pastures are used (3.5 and 2.0 years, respectively). The same value was used for semi-zero grazing, assuming that cut-and-carry forages would be offered only to animals weighing more than 200 kg. Rehabilitation of degraded pastures and the use of rehabilitated pastures as part of a semi-zero grazing system resulted in a 31.2 percent and 42.4 percent shortening of the time needed to reach 400 kg BW, respectively. If animals were fed under the same systems for the finishing phase (400 to 500 kg BW), farmers could save 32.0 percent and 43.1 percent of the total time, respectively, or 2.3 and 3.1 years (table 9.2). The LWG per animal was significantly higher for rehabilitated pastures compared to the control (degraded pastures), at 1.27, 1.55, and 1.13 times higher if comparisons were made for animals between birth and 400 kg, between 200 and 400 kg, and between 400 and 500 kg BW (the finishing phase), respectively. The corresponding values for the most intensive system (semi-zero grazing) versus the control of degraded pastures were 2.03, 2.68, and 1.46, respectively.

Even greater advantages were obtained in terms of beef productivity (kg/LWG/year) as rehabilitation of degraded pastures and use of supplementary fodder as part of the diet resulted in significant increases in the stocking rate. Beef productivity for animals between 200 and 400 kg BW increased 5.43 times due to rehabilitation of degraded pastures and 10.71 times when supplementary fodder was included in the ration as part of the semi-zero grazing system (table 9.2).

Estimates of methane emissions and manure and nitrogen excretion were also obtained from the LIFE-SIM model. Expressed on a per animal-year basis, the production of methane, manure, and N, which all have potential negative effects on the environment, were greater for the more intensive systems because the higher intake obtained in those systems dominated the beneficial effects of the improved quality of the diets; however, when those estimates referred to the productive life of the animals (up to 400 or 500 kg BW), the total emission of methane and the excretion of manure and N were greater in the traditional system than in rehabilitated pastures (table 9.3). This information is relevant for the project because TUSIP promoted more productive and eco-friendly systems. These effects would be recognized if a scheme of payment for ecosystem services was put in place.

TABLE 9.2: Expected Live Weight Gain (LWG) per Animal (kg/day) and Beef Productivity (kg/ha/day) for Animals Raised up to 400 and 500 kg under Three Feeding Strategies Based on Pastures in Tugi Village

PARAMETER	PASTURE/FEEDING STRATEGY		
	DEGRADED	REHABILITATED	REHABILITATED PLUS CUT-AND-CARRY
Stocking rate, animals/ha	0.50	1.75	2.00
Time required to reach 400 kg BW, years	6.3	4.3	3.6
Average LWG from birth to 400 kg, kg/day	0.167	0.212	0.338
Beef production per hectare from birth to 400 kg, kg/ha/year	30.4	135.3	246.6
Average LWG from 200 to 400 kg, kg/day	0.185	0.287	0.495
Beef production per hectare from 200 to 400 kg, kg/ha/year	33.7	183.1	361.1
Time required to reach 500 kg BW, years	7.2	4.9	4.1
Average LWG in the finishing phase (400–500 kg), kg/day	0.370	0.417	0.539
Beef production per hectare in the finishing phase (400–500 kg), kg/ha/yr	67.5	266.4	393.5

Source: Authors.

2 Animal Unit (AU) = A bovine weighing at least 400 kg.

TABLE 9.3: Estimated Methane Emissions, Manure Production, and Total Nitrogen Excretion for Animals Raised up to 400 and 500 kg under Three Feeding Strategies on Pastures in Tugi Village

PARAMETER	PASTURE/FEEDING STRATEGY		
	DEGRADED	REHABILITATED	REHABILITATED PLUS CUT-AND-CARRY
ANIMALS BETWEEN 200 AND 400 KG BW			
Methane emission, kg/animal/period	118.1	105.3	90.4
Manure excretion, kg/animal/period	2201	1839	1368
Total N excreted, kg/animal/period	67.5	60.4	48.0
ANIMALS BETWEEN 200 AND 500 KG BW			
Methane emission, kg/animal/period	171.2	133.2	135.5
Manure excretion, kg/animal/period	3106	2373	2030
Total N excreted, kg/animal/period	94.5	86.5	70.6

Source: Authors.

9.2 ECONOMIC FEASIBILITY OF THE PROPOSED INTERVENTIONS

The economic feasibility of rehabilitation of degraded pastures with or without the use of fodder banks was assessed for two categories of animals: from 200 to 400 kg (the development phase) and from 400 to 500 kg (the finishing/fattening phase). The biological information used for the analysis was generated by the LIFE-SIM simulation model (table 9.2), whereas most of the costs and prices were registered by the TUSIP team. Some assumptions used for the economic/financial analysis were as follows:

1. The period of analysis is 12 years.
2. In scenarios where the pasture rehabilitation component was involved, it was assumed that the process required one year of animal exclusion from the pastures, so no production and income were generated in the first year. The same establishment period was applied in the case of fodder banks.
3. Maintenance of pastures consisted only of limited labor for weed control, and no fertilizers were applied in the degraded pastures; a small amount of fertilizer was applied in the rehabilitated pastures and fodder banks.
4. Animal productivity declined more or less constantly each year in the degraded pastures; at the end of the twelfth year, only 80 percent of the yields obtained the first year was present. In rehabilitated pastures, one year after rehabilitation strategies were applied, productivity was 75 percent of the maximum, 90 percent the following year, reached the maximum in the third year, remained at that level until the sixth year, and started to decline the seventh year, being 70 percent at the end of the twelfth year. It is likely that the productivity decline for the rehabilitated pastures will be less than the figures used, considering that legumes are in the pastures and more rational pasture management strategies would be applied.
5. In all cases, it was assumed that a full vaccination and deworming plus mineral supplementation package was applied in all three cases, although that is not the case in the traditional system.
6. Molasses supplementation (0.5 kg per animal per day) was provided during the four most critical months in terms of forage availability, and this amount was the same for animals weighing from 200 to 500 kg.
7. All scenarios involving rehabilitated pastures required fencing, and as all analyses were done on a per-hectare basis, it was assumed that the paddocks had a square shape, with a 400-m perimeter (100 m per side).
8. In scenarios involving the use of fodder banks, a forage chopper and a corral were considered necessary, but assuming that up to 20 animals could be maintained, those investments were divided by the number of animals maintained per hectare; according to the model used, this was 2.0 AU/ha.
9. For all scenarios, the annual discount rate was 8 percent; however, given that the model used has the option to run sensitivity analysis, estimates of PNV were obtained using rates ranging from 7 to 19 percent.

TABLE 9.4: Net Present Value (NPV) and Internal Rate of Return (IRR) for Rehabilitation of Degraded Pastures and Use of Fodder Banks with Native Cattle in Tugi Village

SCENARIOS	NO SUBSIDIES		50% FENCING COSTS SUBSIDIZED		100% FENCING COSTS SUBSIDIZED	
	NPV, USD	IRR, %	NPV, USD	IRR, %	NPV, USD	IRR, %
Animals between 200 and 400 kg						
Degraded versus rehabilitated pastures	(–488.99)	(–2.95)	(–77.46)	5.50	334.06	30.68
Degraded versus rehabilitated pastures plus fodder bank	92.77	9.09	524.87	15.71	936.39	26.65
Animals between 400 and 500 kg						
Degraded versus rehabilitated pastures	(–101.15)	6.13	310.38	16.13	721.90	40.13
Degraded versus rehabilitated pastures plus fodder bank	32.70	8.38	464.8	14.62	876.32	24.63

Source: Authors.

The results shown in table 9.4 indicate that under these assumptions, rehabilitation of degraded pastures resulted in a negative present net value (PNV), regardless of the production phase (growing or finishing); PNV became positive only when animals were between 400 and 500 kg BW and 50 percent of the fencing costs were subsidized. In contrast, supplementation with fodder during the four most critical months of the year always resulted in positive PNV, although the best response in this case was observed for growing animals (200 to 400 kg BW). The IRR was negative (–2.95 percent) only when pastures were rehabilitated and used by growing animals (200 to 400 kg BW), while the use of fodder banks always resulted in positive IRR values. In the absence of subsidies, the highest IRR value (16.13 percent) was obtained when rehabilitated pastures were used by animals in the finishing phase (400 to 500 kg BW).

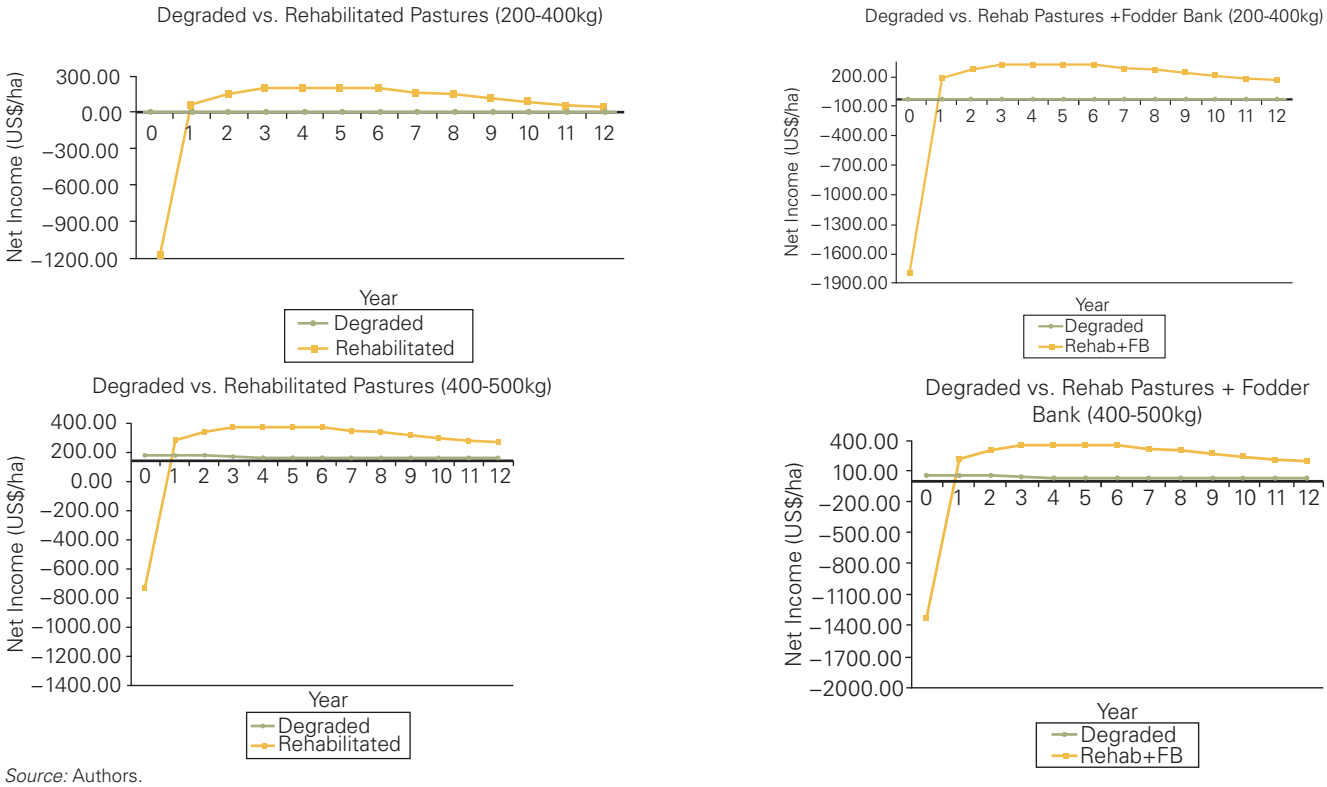
The IRR values obtained for the technology innovations promoted by TUSIP were lower than previous results obtained for different silvopastoral interventions applied by CATIE and the Livestock and Environment Program (GAMMA) in Central America (Hänsel 2008). This is attributed to the investment in fencing; given that this practice is not commonly used in the NWR cattle systems, there was a heavy impact on rehabilitation costs. In contrast, in Central America, most of the investments for rehabilitation of degraded pastures are in seeds, weed control, and associated labor. When it was assumed that 100 percent of the investment in fences was subsidized, similar IRR values (more than 25 percent) to the ones obtained in Central America by Hänsel (2008) were obtained, confirming this hypothesis.

Figure 9.1 shows the change in net income for four scenarios: (1) Animals graze rehabilitated pastures and weigh between 200 and 400 kg; (2) the same as (1) but animals receive chopped forages as supplements; (3) the same as (1) but animals weigh from 400 to 500 kg; and (4) the same as (2), but animals weigh 400 to 500 kg. Figures 9.2 and 9.3 show the variations in net income for the same scenarios described in figure 9.1, assuming that 50 and 100 percent of the fencing costs are subsidized, respectively.

In the case of degraded pastures, net income was negative but very close to zero, varying from USD –2.69 in Year 0 to –12.08 in Year 12 for animals in the growing phase (200 to 400 kg BW). For animals in the finishing phase (400 to 500 kg BW), net income was still low but positive (from USD 97.54 in Year 0 to 78.03 in Year 12). When pasture rehabilitation strategies were applied, the net income for animals weighing between 200 and 400 kg was largely negative in Year 0, as all costs associated with rehabilitation were charged to that year; net income was slightly positive in Year 1 (USD 39.17), reached the maximum in Years 3 to 6 (USD 164.15), and declined to USD 161.37 in Year 12. A similar trend is observed for heavier animals (400 to 500 kg BW): net income declined from USD 44.46 in Year 0 to USD 25.63 in Year 12 when degraded pastures were grazed and increased to a maximum of USD 261.38 in Years 3 to 6 when forages harvested in a fodder bank were fed to the animals.

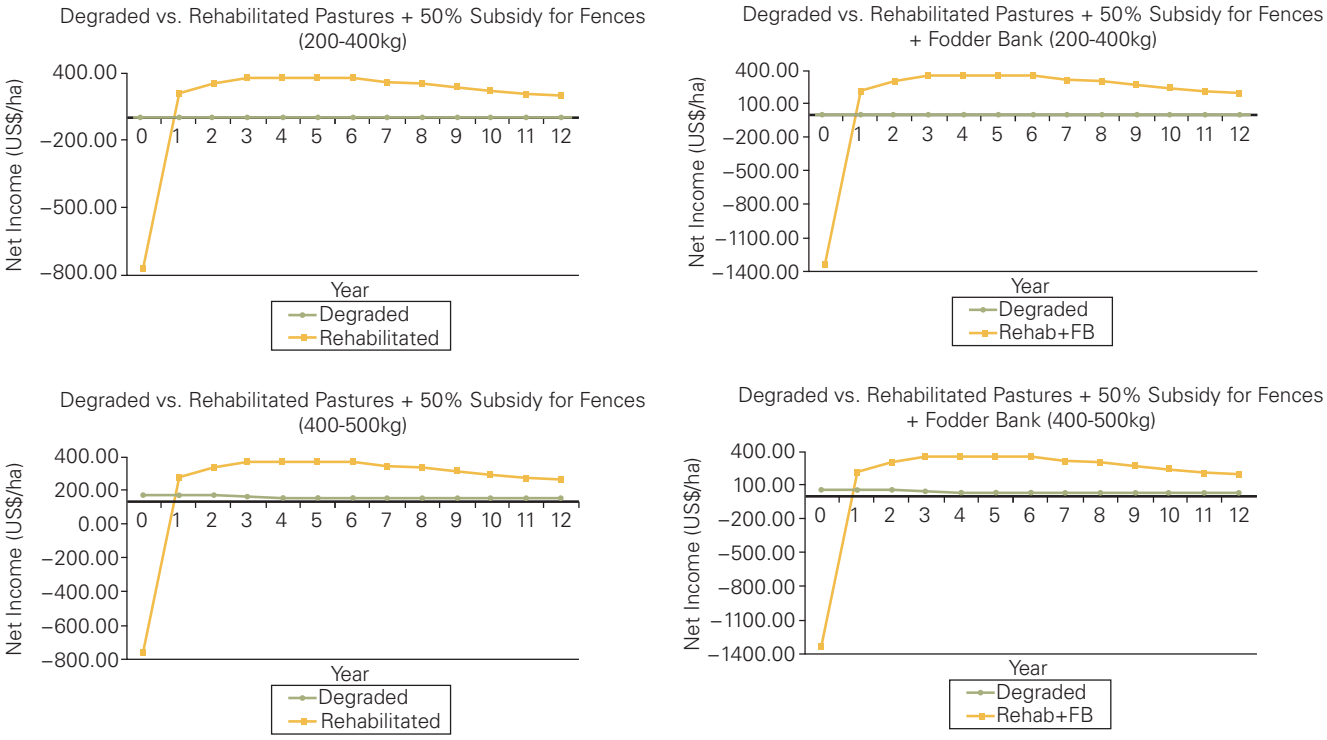
The results obtained for scenarios assuming that 50 and 100 percent of the fencing costs were subsidized yielded the same results in net income for Years 1 to 12 as described above, but there was a significant reduction in the negative income of Year 0, as that was when all fencing costs were charged.

FIGURE 9.1: Changes in Net Income (USD) Due to Rehabilitation of Degraded Pastures and Use of Fodder Banks with Growing (200–400 kg BW) and Finishing (400–500 kg BW) Animals, under the Conditions of Tugi Village



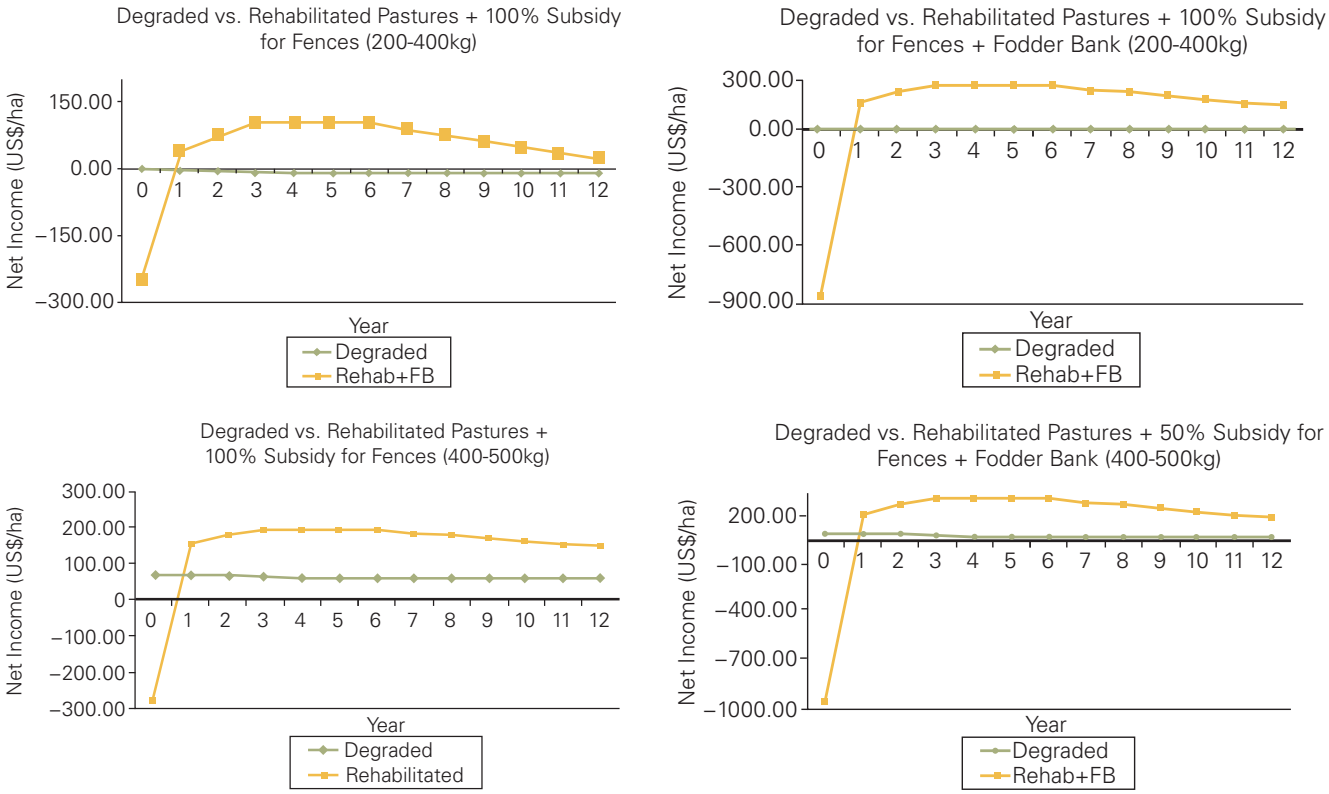
Source: Authors.

FIGURE 9.2: Changes in Net Income (USD) Due to Rehabilitation of Degraded Pastures and Use of Fodder Banks with Growing (200–400 kg BW) and Finishing (400–500 kg BW) Animals, Assuming 50 Percent of Fencing Costs Are Subsidized



Source: Authors.

FIGURE 9.3: Changes in Net Income (USD) Due to Rehabilitation of Degraded Pastures and Use of Fodder Banks with Growing (200–400 kg BW) and Finishing (400–500 kg BW) Animals, Assuming 100 Percent of Fencing Costs Are Subsidized



Source: Authors.

Chapter 10: INVESTMENT IN FARMS

Some of the technologies described in previous sections of this report required some investment (such as construction of fences on rehabilitated areas and fodder banks, construction of the tree nursery, planting materials for rehabilitation of degraded pastures, and so forth). Project staff and farmer partners agreed that the materials and a large proportion of the labor costs required to implement any technology innovation to be tested or used for demonstration purposes would be covered by project funds.

All investments in the Gyindong Community Farm were fully covered with project funds, not only those related to technologies promoted by TUSIP, but also the improvement of facilities on the farm, as the farm belongs to the community and is an area where all farmers can learn. Thus, construction of a herdsman's house (two buildings) with storage facilities, corrals, and water provision; the fabrication of a forage chopper; and the purchase of animals were all covered by the project (figures 10.1 to 10.4). In the case of the latter, some animals will be used for genetic improvement of the cattle maintained on the pilot farms and eventually of other herds in Tugi Village.

Although the animals purchased for TUSIP were bought from reliable sources (such as Institute de Recherche Agricole pour le Développement (IRAD)-Bambui, PRTC-Nfonta, and a government farm [SODEPA–Jakiri/Dumbo]), as a precautionary measure, all animals were first quarantined on a farm. The Community Farm at Gyindong was the preferred choice, but given the urgency to bring the animals before the project finished, the facilities available, and the slow progress upgrading current installations on the other pilot farms, Munoh Farm was selected as the quarantine station. Project staff collaborated to redesign the corrals already available there and defined the provision of water, but all costs associated with this construction were borne by the farm's owners (figures 10.5 to 10.8). Changes made in the corral at Munoh Farm included construction of feeders and a water trough with a roof and a contention crutch and placement of stone pavement in the corral to prevent excess mud from accumulating during the rainy season (figure 10.9). The farm owners also built a herdsman's house close to the corrals (figure 10.10).

The CATIE technical advisor prepared some recommendations related to the quarantine scheme and selection of

FIGURE 10.1: Main House for the Herdsman and His Family at Community Farm in Gyindong

Source: Authors.

FIGURE 10.2: Side View of Herdsman's House

Source: Authors.

FIGURE 10.3: Building to Complement the Herdsman's House, Including Storage Rooms

Source: Authors.

FIGURE 10.4: Another View of Secondary Building

Source: Authors.

FIGURE 10.5: Corral Gate at Munoh Farm

Source: Authors.

FIGURE 10.6: Feeders and Drinking Trough at Munoh Farm

Source: Authors.

FIGURE 10.7: Stone Pavement Corral Floor at Munoh Farm

Source: Authors.

FIGURE 10.8: Corral's Contention Crutch at Munoh Farm

Source: Authors.

FIGURE 10.9: Drinking Trough and Water Control System

Source: Authors.

FIGURE 10.10: Herdsman's House at Munoh Farm

Source: Authors.

animals purchased. Some of the recommendations with respect to animal health issues were as follows:

1. Animals must be tested for relevant transmissible diseases. To determine which are relevant in the region, it was suggested that an experienced veterinarian be consulted.
2. Animals must be sprayed or, even better, dipped to eliminate external parasites and must also be dewormed.
3. All animals should be maintained and observed on one farm for at least 40 days. In addition to the factors cited above, another advantage of quarantining at Munoh Farm was its accessibility and proximity to the village.

Regarding the selection of animals to be purchased, the recommendations were as follows:

1. *Type/Breeds of Animals*: This depends on the purpose of the exploitation and the prevalent conditions on the farms where animals will be introduced. Decision makers in TUSIP and Tugi Village indicated that there is interest in moving eventually to milk production, which requires good conditions and special training of farm operators, and a clear identification of market opportunities. Based on this, the suggestion was to start with a dual-purpose system, such as the one practiced at the Mbengwi Monastery, some 18 km from Tugi. The Gudali and Red Mbororo/Fulani breeds show more characteristics of milk production–oriented cattle than the White Fulani. Either one of the first two should be the basis for a crossing program, and the females purchased should belong to either of those two breeds. In the case of bulls, the European dairy breeds (such as Holstein, Simmental, or Jersey) may have problems adapting to Tugi conditions. Therefore, to make quick genetic progress, crossbred bulls, either Gudali or Red Mbororo crossed with Holstein or Simmental, should be sought depending on market availability (figures 10.11 to 10.14).

FIGURE 10.11: Young Crossbred Bull from Jakiri (with a Low Proportion of Holstein Genes)

Source: Authors.

FIGURE 10.12: Type of Animals Purchased at PRTC-Nfonta

Source: Authors.

FIGURE 10.13: Type of Animals Purchased at SODEPA-Jakiri

Source: Authors.

FIGURE 10.14: Crossbred Gudhali × Holstein Young Cow

Source: Authors.

2. *Age of Cows and Bulls*: All may agree to start with young animals, but the fertility status of the animals should be checked. Cows should have had one or two calvings at most. In the case of bulls, minimum age is not relevant because of the variability in growth rates observed in the NWR, but young bulls that are ready for reproduction should be selected.
3. *Reproductive Ability*: The main interest in bringing the animals to TUSIP farms is to improve or initiate efficient cattle production activities. A basic condition for this is to bring healthy animals with proven reproductive ability. Although pregnant heifers or young cows could be a good choice, it was recommended to avoid purchasing these given difficulties with transportation to Tugi; hence, cows that have calved once or twice already should be sought. For bulls, a sperm analysis should be done to check for viability.

Chapter 11: DEVELOPMENT OF LOCAL CAPABILITIES FOR IMPLEMENTATION OF SILVOPASTORAL SYSTEMS

Farmers in Tugi practice traditional systems because their access to modern technical knowledge in agriculture is almost nil, as the official innovation system is almost nonexistent in the Gutah Hills. The presence of the government institutions responsible for topics related to the silvopastoral systems covered by TUSIP is very limited; in some cases, their role is mostly regulatory (such as granting permits for tree harvesting and controlling animals brought to the Acha-Tugi Cattle Market) or for the control of animal diseases (such as livestock vaccination campaigns). Tugi has two extension posts, one for agriculture and one for veterinary and animal husbandry services, but only the latter has a resident staff. Neither has a formal, structured training program for farmers. Very few villagers have had access to innovations in livestock and crop production. Two residents of Tugi-Tugi attended technical training in animal husbandry and veterinary services, but only one was applying his training on his own farm, and he very seldom offered services to others. Only one woman reported that she attended trainings at the PRTC.

Based on the above, the technical advisor planned to apply participatory learning and experimentation methods, starting with the identification of problems and opportunities, participatory curricula development, and design and implementation of innovations, as well as participatory monitoring and evaluation (Groeneweg *et al*. 2006). However, full application of this approach was limited initially by the fact that farm operators were expecting project staff to tell them what to do, instead of participating actively in the decision-making process. Moreover, the duration of the project (22 months), along with the proximity of the first rains that define the proper timing for planting, forced project staff to apply a traditional top-down approach, but they kept in mind the need to identify strategies to ensure ownership of the innovations by farm operators in the future.

At the beginning of the project, farm operators were only observers of the changes they authorized project staff to make on their plots. It took almost six months for them to become actively involved, accompanying the staff in the field activities carried out on their farms, participating in the group learning sessions, and eventually even identifying and implementing their own innovations (such as planting vegetative materials for live fencing) and replicating the innovations in other areas of their farms. In this respect, the process was not easy, but the village authority (HRH Wilson Mbakwa IV, Fon of Tugi) was instrumental in facilitating changes in the attitude of farm operators, such that ownership of project innovations by different project stakeholders can now be recognized.

11.1 PARTICIPATORY LEARNING SESSIONS

Decisions regarding which learning sessions to hold and when and how to develop them were sometimes opportunistic, based on technology innovations or practices needed at a given time on the pilot farms, but some sessions were designed specifically to analyze the work done by a group. However, in all cases, participating groups were selected based on their interest and on the potential for replication of the innovations discussed. The hands-on or *learning by doing* principles that characterize the FFS approach (Aguilar *et al*. 2010; Minjauw *et al*. 2004; Pezo, Cruz, and Piniero 2007) were applied, and all learning sessions were held directly on the pilot farms.

The topics covered in the learning sessions were as follows:

<u>Rehabilitation of degraded pastures</u>

1. How to build fences for better pasture management
2. What is a weed in a pasture and how to control it
3. Enriching pastures by oversowing valuable grasses and legumes
4. How pasture establishment can fail

<u>Management of tree nurseries</u>

1. Growing trees in bags: the tree nursery management
2. Drafting and marcotting as a means to get better fruit trees

Other learning sessions

1. Planting grasses and legumes in fodder banks
2. Fire tracing: a strategy for preventing pasture losses during the dry season.

Rehabilitation of Degraded Pastures

The methodologies applied in each session varied with the topics and participants. For example, the one on building fences (session 1) was carried out in several practical sessions with different groups of workers who participated actively in building the fences for all pilot farms; after completing the fencing on at least three pilot farms, a review session was held with the youth who participated in the work plus representatives of the families who own the pilot farms. A special session on the same topic was also held for the Fulani livestock keepers. The session on weed control (session 2) was conducted with the people who participated in controlling weeds on the pilot farms, but one learning session was held before starting the practical work to clarify which species could be considered weeds, thereby preventing the elimination of valuable species (figure 11.1). A similar strategy was applied in the case of the session on how to introduce improved grasses and legumes for rehabilitation of degraded pastures (session 3). Finally there was a review lesson (session 4) to analyze the strategies applied for rehabilitation of degraded pastures and the results obtained planting grasses and legumes (including the ones in the fodder banks) (figure 11.2). Workers and farm operators participated in this session.

The themes described above constituted an FFS on Rehabilitation of Degraded Pastures and Fence Building. In October 2010, as part of a program prepared to coincide with a World Bank Operational Mission, certificates were awarded to those who satisfactorily completed the training. Although about 50 men from Acha-Tugi, Tugi-Tugi, and Tuochup-Chup participated in the different learning sessions, only 25 of them received the certificate. It is important to note that people trained by the project started applying the knowledge acquired from similar activities programmed as part of the Gender Mainstreaming Component and replicating the innovations on other farms in the area or extending the areas under rehabilitation in some of the pilot farms.

Management of Tree Nurseries

Learning sessions on establishment and management of tree nurseries and other techniques relevant for installing agroforestry innovations (sessions 5 and 6) were offered as part of the collaborative work with ICRAF (figure 11.3). Given that

FIGURE 11.1: Youth Participating in a Weed Control Session

Source: Authors.

FIGURE 11.2: Review Session on How to Build Fences

Source: Authors.

ICRAF staff had to come to the village, those trainings were organized as a short intensive course over three days (26–28 July 2010), again using the *learning by doing* training approach. Twenty-three women and ten men completed the training and received a certificate when the World Bank Operational Mission visited Tugi. The ICRAF facilitator made two follow-up visits to interact with the course participants and monitored progress in the nursery and tree propagation work.

In the training offered by ICRAF staff, participants were introduced to the methods of plant propagation in polyethylene bags, as well as in the three main vegetative techniques used for the improvement and propagation of trees—marcotting, grafting, and propagating by cuttings. These techniques

FIGURE 11.3: Youth Preparing the Substrate for Growing Trees

Source: Authors.

were applied with guava (*Psidium guava*), kola nut (*Kola nitida*), and African plum (*Prunus aficana*), respectively.

Other Learning Sessions

The session on the establishment of fodder banks (session 7) was conducted initially with the women's groups who volunteered for planting the cut-and-carry forages. There were two separate sessions, one in Tugi-Tugi and another in Tuochup. Afterward, the gender specialist applied the guideline developed when she trained the different women's groups who established fodder banks for the sheep and goat units promoted under the TUSIP Gender Mainstreaming Component. Moreover, the women who participated in the training sessions offered by the silvopastoral component shared the knowledge already acquired with others.

Accidental fire is a well-known problem in the village and the rest of the region. During the dry season of 2010, the technical advisor witnessed at least three fires in Tugi. To prevent problems with the rehabilitated grazing areas where there was an accumulation of large amounts of standing biomass, project staff did fire tracing around the pastures. The work formed the basis for a participatory learning session attended by 25 workers and farm operators from Tugi-Tugi, Acha-Tugi, and Tuochup-Chup (figure 11.4). Topics covered included the common causes of fire, the consequences of fire on the pasture and on the environment, and the different management strategies used to prevent bush fire from spreading.

An important aspect of the participatory learning sessions was that in all sessions, participants made their own contributions, citing and sharing some local knowledge, such as identification of nonforage species that have value as medicinal plants and spices, the use of local tools for land preparation before planting and for tensioning the fences, making modifications in the design of paddock gates, and so on (figures 11.5 to 11.8). After the trainings, the pilot farm heads and others replicated the innovations on their own farms, as did some heads of nonpilot farms. Among the latter, Mr. George Tah (then mayor of the council with jurisdiction over the project community) established more than 1 ha of fodder banks and built fences following the models implemented by TUSIP, and Mr. Andrew Tayong (staff of NWR-based African

FIGURE 11.4: Graduates of the Tree Nursery Management Training

Source: Authors.

FIGURE 11.5: Women Carrying Guatemala Grass Cuttings

Source: Authors.

FIGURE 11.6: Women Discussing How to Plant Fodder Banks

Source: Authors.

FIGURE 11.7: The Gender Specialist Applying Participatory Methods in Training a Women's Group

Source: Authors.

Development Bank (AfDB)-funded rural development project) and his brother oversowed more than 2.0 ha of degraded pastures with *Brachiaria ruziziensis.* After the training session on fire tracing, the pilot farm family heads took it upon themselves to replicate the fire control measures on their farms, as did two nonpilot farmers (Mr. Isaiah T. Chick and Mr. Andrew Tayong).

Other planned learning sessions could not be carried out, such as ones on hay making, preparation of multinutrient

FIGURE 11.8: The Research Assistant Applying Participatory Methods in Training a Men's Group

Source: Authors.

blocks, preventive animal health practices, design and construction of corrals (although some corrals were built with the participation of villagers), and others. Training on the use of mineral supplements for cattle and sheep was planned to be held before project completion.

11.2 PREPARATION OF EXTENSION BULLETINS AND LEAFLETS

TUSIP's experiences implementing some of the technology innovations were documented in extension bulletins and leaflets, as project staff could not find any literature produced in the country that could be used as a reference for FFS facilitators, technical staff, and farmers. A Manual on Shrubs for Feeding Animals (Wambugu *et al.* 2006) and several Extension Fact Sheets on fodder trees and alley farming were obtained from ICRAF, which helped TUSIP staff prepare materials for training.

The publications prepared under TUSIP were written in English, designed as support tools for the participatory learning process, and distributed among farm operators and workers who were able to read; however, they could also be used by technical staff of NGOs and government officials interested in the rehabilitation of degraded pasturelands and the implementation of silvopastoral systems. Very few copies of each have been printed, but they have been posted on the AMF website for consultation and eventual use in training.

The bulletins and leaflets published are as listed:

1. "How to build fences for improved pasture management" (Pezo and Azah 2010c)
2. "How to control bracken fern (*iwheungh*) in the Gutah Hills" (Pezo and Azah 2010d)
3. "Planting grass/legume fodder banks" (Pezo and Azah 2010e).

A fourth bulletin describing the experiences in the rehabilitation of degraded pastures was to be prepared, but it was not possible to complete it due to limited time and resources. These publications need to be complemented by the corresponding Extension Fact Sheets, ideally illustrated with drawings for those who cannot read and write, but project staff were not able to work on those given the limited availability of time. These publications would also be useful if and when TUSIP is scaled up.

11.3 TRAINING PROJECT STAFF

Strengthening the technical capability of partner institutions to improve the livelihoods of the rural population through integrated management of agriculture and natural resources is part of CATIE's mandate. Therefore, training TUSIP counterparts in Cameroon was a task assigned to the technical advisor, although it was not explicitly stated among the project objectives. In this context, methodologies, research tools, and field experiences were shared in a one-on-one interaction during the two periods (seven months) that the professional assigned by CATIE was working in Cameroon, as well as through the Internet when he was in Costa Rica and elsewhere. A similar strategy was applied when the technical assistant was trained in Costa Rica.

The technical advisor was also a liaison with the AMF for implementing administrative procedures acceptable to CATIE and the World Bank; therefore, project administrative staff and the research assistant shared ideas on how to design templates in Excel to report expenditures and to analyze progress in budget execution.

The following sections describe the activities conducted to train the AMF staff in technical matters.

Assessment of the Pasture Degradation Status

The decision on when and how to rehabilitate degraded pastures is a function of the level of degradation; as the project was in a zone where pasture degradation was a limiting factor for efficient livestock production, one of the first training efforts was to introduce the research assistant (who eventually became the field assistant) to the methods for assessing the status of degradation in pastures. This was complemented later with training on how to estimate forage availability in pastures using the BOTANAL system.

Participatory Learning and Experimentation Methodologies

The technical assistant and the gender specialist were introduced to the methodologies used for group learning sessions applying the FFS approach. Moreover, CATIE's technical advisor worked with the TUSIP technical assistant to prepare learning session guidelines and to facilitate sessions in the field. Although the latter may need additional training on participatory methodologies, he is already prepared to independently facilitate FFS sessions (as demonstrated by his facilitation of the fire tracing session).

Implementation and Management of Some Silvopastoral Innovations

The technical assistant and field assistant were trained in the implementation of several silvopastoral options, some of them already implemented in Tugi. The technical assistant was also trained on the use of the LIFE-SIM simulation package to assess year-round feeding strategies, on the use of GIS packages, on rotational pasture management, and on other techniques. Some of those were part of his three-week training held in Costa Rica. For the gender specialist, special training sessions were carried out on the design of elevated pens for small ruminants, on the establishment and management of fodder banks, and on the use of local feed resources to feed small ruminants, among other topics.

Training of the TUSIP Research Assistant at CATIE Headquarters

Mr. Chick Herman Azah was trained in Costa Rica from 7 to 29 March 2011 (figures 11.9 and 11.10). After induction in CATIE, including visits to its facilities and special training on the rich bibliographic collection available at the library, Mr. Azah participated in several individual training sessions with CATIE specialists on the following topics: pasture evaluation techniques, grazing management, silvopastoral options, establishment and management of fodder banks, design of year-round feeding strategies, supplementary feeding of cattle and small ruminants using multinutrient blocks, forage seed production, participatory mapping using GIS techniques, and planning of agronomic trials for the evaluation of forage

FIGURE 11.9: The TUSIP Research Assistant Checking a Simple Fodder Chopper in Santa Cruz de Turrialba (Costa Rica)

Source: Authors.

FIGURE 11.10: The TUSIP Research Assistant Learning about *Cratylia argentea* (a Fodder Tree) at UTN/ECAG in Atenas (Costa Rica)

Source: Authors.

germplasm. These learning sessions were complemented with field visits to farms located in the humid and subhumid tropics, as well as of the highlands of Costa Rica, in which he had the opportunity to talk with farm owners. In those visits, he was exposed to dairy and beef cattle and goat systems, as well as to the processing and commercialization of livestock products and live animals. As a result of the interactions with researchers and lecturers of two CATIE partner institutions in Costa Rica (The Central American School for Livestock Production [ECAG], and the Ministry of Agriculture), it was possible to obtain more forage seeds for testing, some for low and mid-altitudes, and others for the highlands of Tugi.

Chapter 12: UNDERSTANDING FARMERS' PERCEPTIONS AND EXPECTATIONS OF PROJECT INTERVENTIONS

Given the short duration of the project and the length of the pasture rehabilitation processes, as well as the time required for implementing silvopastoral options, it was not possible to make a thorough assessment of farmers' perceptions on the impacts of the innovations. However, based on informal conversations with farm operators, workers, and other villagers, some preliminary conclusions could be drawn.

All people visiting the pastures where rehabilitation strategies were implemented noticed clear differences in pasture composition and herbage availability between the intervened and control paddocks. Some of the noticeable advantages included the increase in the availability of edible grasses and legumes, the reduction in the infestation of bracken fern and other weeds, enhanced erosion control, and so forth. It was not possible to get estimates of the impacts on animal productivity, given the time elapsed and the fact that new animals were still being purchased for some of the farms. However, there were indirect indications of how farmers perceived those changes. There has been already some limited replication of the pasture rehabilitation techniques in the pilot farms as well as in at least three of the nonparticipating farms.

Adoption is a slow process but is even slower when investments are required and farmers have economic resource limitations. The pasture rehabilitation strategies *per se* were low cost, but the cost of fencing was the most limiting factor. There is no doubt that the investment could be recovered with higher productivity (as demonstrated earlier), but there was a need for initial capital to do so. Means for financing the replication of project experiences need to be sought. Project staff simulated several scenarios demonstrating the economic feasibility of implementing the proposed technology innovations, but an *in vivo* demonstration is needed and should be one of the first efforts developed after the project ends.

Another benefit of the intervention appreciated by participating farmers was that animals could be maintained in the village year round; there is no longer a need for transhumance during the dry season with the corresponding social/family implications.

The main targeted vulnerable groups (unemployed youth and women) recruited offered their labor to implement the technology innovations promoted by TUSIP; they got a wage in return (USD 5 per day, which is over the minimum wage paid in the area). Youth (mainly male) were hired for all pasture rehabilitation work (for example, to cut and carry poles, build dead fences, control weeds, oversow pastures, and conduct fire tracing), while faith-based women's groups were hired to plant the fodder banks and oversow grasses and legumes in rehabilitated pastures. In addition to the wages earned, all workers participated in learning sessions that prepared them to replicate the experiences in other farms (thereby eventually earning money for doing so).

It is also important to note that some unemployed youth from Tugi who were living in cities and exposed to other vulnerabilities associated with city life heard of the project and were attracted by the employment opportunities created by TUSIP. Many of those who returned found a job with the project, used the income gained to provide for themselves and their significant others, and are now living a more dignified life in the village. The women used the income generated to procure more basic social needs (such as school uniform and material, improved nutritional and medical needs covered for themselves and their children). Many started saving some of the money earned through the traditional savings organization that operates in each quarter, and a microfinance organization is in the process of being established in Tugi to provide formal rural financial services to these new income or wage earners, creating potential demand for such services.

Chapter 13: RAISING AWARENESS ON TUSIP OBJECTIVES AND ACTIVITIES

TUSIP started by organizing meetings with local leaders and representatives of the target community to explain the purpose of the project and its proposed activities to develop ownership within the community. The technical advisor participated in meetings developed in Tugi-Tugi and Acha-Tugi and later visited the fon and kingmakers of the neighboring village Ngwokwong; the research assistant also made a presentation in another neighboring village (Oshie). Those meetings were attended by representatives of the two ethnic groups (Meta and Fulanis) that constitute the majority of the population.

Besides these, at least four workshops or presentations were organized by the TUSIP leader with authorities governing the area where the project operates to sensitize the public, raise awareness, and increase buy-in for TUSIP. The technical advisor assigned by CATIE participated in at least three of those (figure 13.1). The authorities deemed as strategic partners included the senior divisional officer for Momo Division, his first assistant, the district officer for Mbengwi Central, the mayor of the Mbengwi Council, and heads of relevant technical ministerial departments in the Divisions of Agriculture, Livestock, Environment, Forestry and Natural Resource Management (figure 13.2); they each pledged their individual and collective support to see the project succeed in rehabilitating grazing vegetation, managing erosion, and introducing silvopastoral technologies aimed at curbing rampant and sometimes lethal conflicts between crop and livestock farmers.

Project Management Committee (PMC) meetings have taken place since inception of the project with at least five ordinary and three expanded PMC meetings convened during the time the technical advisor was in Cameroon, at which progress made by the project was discussed and documented. In PMC meetings, its regular members, the hierarchy of the Tugi Cultural and Development Association, and the Tugi Livestock Farmers' Cooperative received updates from the PMC chair, CATIE's technical advisor, and the project's research assistant. Following each meeting, members were charged with the responsibility to go back to the community to educate people on the objectives and expectations of the project. Some of the techniques developed were documented in flyers and disseminated at meetings

FIGURE 13.1: CATIE Technical Advisor Presenting TUSIP to Government Officials in Momo Division

Source: Authors.

FIGURE 13.2: Participants in a Workshop Held in Mbengwi to Present a TUSIP Progress Report

Source: Authors.

through PowerPoint presentations and hard copies and to others by e-mail with electronic copies of the flyers attached. In addition, press releases were prepared and distributed among journalists representing newspapers and radio stations with coverage in the NWR. Also, when the World Bank Operational Mission visited the project, staff of the national radio and television system (Cameroon Radio and Television) accompanied the delegation and prepared a series of reports on the project and the technologies promoted, and those were presented nationwide on several occasions.

Chapter 14: ESTABLISHMENT OF PARTNERSHIPS

The project tried to establish links with several institutions in addition to the government institutions cited in the previous section. At the local level, the PRTC, Nfonta, IRAD, and HPI were approached. PRTC-Nfonta helped TUSIP locate and procure seeds and seed materials that were tested for adaptability in the project area and could become a provider of some of the cattle to be purchased with TUSIP funds. No further interactions were established with IRAD after the initial visit to learn about their research activities. HPI was identified as a potential partner considering their areas of interest; although one of its staff attended two of the project meetings, no commitments were made by HPI to participate in project activities, but HPI could be a potential partner in a new project. Although the University of Dschang was not a formal partner, it provided analyses of soil, water, and blood samples sent by TUSIP, and more recently staff of the Faculty of Agriculture and Agricultural Sciences contributed ideas for the preparation of a Concept Note for extending the experiences developed by TUSIP. Moreover, some of the university staff expressed interest in participating in the new project.

Among the CGIAR centers, ILRI and ICRAF supported different TUSIP activities. Their role providing germplasm, information, and training was described in previous sections of this report, and more involvement of those institutions in a new project is foreseen.

Chapter 15: A PROPOSAL FOR SCALING TUSIP LESSONS LEARNED "UP AND OUT"

TUSIP is a success story of South-South cooperation, having adapted technology innovations developed in Central America to the circumstances of the Gutah Hills, resulting in rehabilitation of degraded pasture lands, improved livestock productivity, increased income of rural communities, and reduced risk and vulnerability to climate change. The Gender Mainstreaming component initiated in the second part of 2010 demonstrated the relevance of effective incorporation of village women's groups, to support not only implementation of silvopastoral technology innovations, but also other activities that respond more directly to women's main role in agricultural production, creating an environment for harmonious crop-livestock integration whereby food crops and livestock are raised to promote the livelihoods of farm families as a whole.

Based on the above, CATIE, in collaboration with its partners in Cameroon, prepared a Concept Note titled "Increasing Productivity and Reducing Vulnerability to the Climate Change as Strategies to Improve the Livelihoods in Poor Agro-Silvopastoral Communities of the Gutah Hills of Cameroon," as an effort to scale up and out the lessons learned in TUSIP's 22 months of operation. This initiative is proposed to be conducted in partnership with the current local partner, AMF, ILRI, and ICRAF, as well as other Cameroonian government institutions and NGOs. The proposed project is for four years, with a total budget of USD 3,050,000.

The leader of GAMMA submitted the Concept Note to the World Bank and discussed submitting it as a joint proposal to potential donors with the newly elected Director General of ILRI and a representative of ICRAF. CATIE already contacted IFAD as one of the potential donors but will continue seeking other donors.

Chapter 16: THE WAY FORWARD

TUSIP closed on 30 September 2011, but there are still several activities that need to be followed up on to ensure that the impact of the project continues and, more importantly, is enhanced. The work with pastures in general, and more specifically in applying silvopastoral approaches, requires time for installing technology innovations, and for evaluating those under livestock management. During the period covered by the project operation, some technologies were implemented and some evaluations were started. Simulation programs were needed to predict the impacts of the innovations in the long run. Recovery of degraded pastures takes at least one year before animals can be introduced into rehabilitated paddocks, and the same applies to fodder banks. The purchase of animals was delayed until the pastures, corrals, and herdsmen's houses were ready—pasture evaluations can be effectively conducted only after this. Also, the project introduced new forage germplasm in the area, which needs to be tested under controlled conditions for at least two years before introducing it in production systems. Advice was provided to consider efforts for multiplying those pasture and tree species identified as promising, either through the production of seeds or vegetative multiplication.

It was impossible to obtain data on the sustainability of the proposed technologies in less than two years, but this was known during the project planning phase. Therefore, efforts were made to train local staff and farmers to continue implementing, monitoring, and extending the results obtained.

CATIE is interested in continuing to support its partners in Cameroon and in being part of further efforts to scale out the lessons learned in TUSIP. For that purpose, CATIE contacted potential donors to provide the funding for the new project as already described. Moreover, CATIE will continue contacting its local partners to share new findings and to identify solutions to any problems detected with the technology innovations put in place in Tugi.

Chapter 17: BUDGET EXECUTION

The World Bank's contribution to TUSIP was USD 195,000, received by CATIE, but according to project planning, 56.4 percent of that was transferred to AMF for TUSIP operations in the field. More than 90 percent (90.6 percent) of the fee amount assigned to CATIE was also spent in Cameroon. A funds use analysis of the amounts allocated up to the end of the project extension (30 September 2011) is presented in table 17.1.

TABLE 17.1: TUSIP Financial Report for the Period 1 November 2009 to 30 September 2011

ITEM	BUDGET (USD)	EXECUTED BY SEPTEMBER 30, 2011 (USD)	EXECUTION RATE BY SEPTEMBER 30, 2011 (%)
International consultant fees	57,000.00	57,000.00	100.00%
Transactions costs/processing fees	8,000.00	8,000.00	100.00%
Local consultant fees	20,000.00	18,955.70	94.78%
Travel	20,000.00	20,000.00	100.00%
Dissemination (workshops, publications, Web)	10,000.00	10,234.31	102.34%
Others (investment on farms)	80,000.00	80,809.97	101.01%
Total	**195,000.00**	**194,999.98**	**100.00%**

Source: Authors.

Chapter 18: SOME FINAL REFLECTIONS

- Natural resources (forest cover and soils) are already seriously degraded in the Gutah Hills, affecting the productivity of crop-animal systems and the livelihoods of the communities. Water availability is not yet a limiting factor, but its quality is already a problem.
- The nonsustainable land-use management practices currently applied reduce the feasibility of mitigating climate change impacts.
- The silvopastoral innovations promoted by TUSIP are options to rehabilitate degraded lands, increase animal productivity, reduce the time required for animals to reach the market, mitigate the emission of greenhouse gases per kilogram of animal product and per animal life span, increase the potential for carbon sequestration, and, more importantly, contribute to improving the livelihoods of farming communities.
- The main constraint to implementation of such innovations is the availability of capital for investment; therefore, subsidies or payments for ecosystem services schemes need to be implemented to make these options feasible.
- In the Gutah Hills, farmers' access to technology information and to adequate market channels is almost nonexistent; however, the application of participatory approaches for learning and experimentation, as well as the effective involvement of existing groups in production and transformation processes, are ways to contribute to alleviating poverty in rural communities.
- The nature of the problems faced by farmers requires a holistic approach and cooperation of stakeholders with different backgrounds and interests (including government and nongovernment institutions and local leaders) working together for development.
- TUSIP is an example of the importance of promoting South-South cooperation in silvopastoral technology/knowledge transfer given the similarities among tropical countries in terms of agro-ecological conditions and production systems, as well as the globally relevant threat of climate change.

Appendix: SELECT COMMENTS FROM PEER REVIEWERS AND RESPONSES BY AUTHORS

I. COMMENTS BY RETIRED WORLD BANK SENIOR ADVISOR IN LIVESTOCK (NOW CONSULTANT AT THE WORLD BANK)

1. ***What are the drivers of the reported strong uptake of the technology? (a) Is it lack of awareness of the technology, as the report seems to indicate, but is hard to believe for me, as these technologies are not new; (b) the subsidy level, while it might be in the report, I didn't get a clear idea of the total level of subsidy of the farms; or (c) the fencing, as a means of getting individual access to land?***

   (a) The technologies proposed by TUSIP are not new in many other places, but as indicated in the report, livestock extension services in the area where the project operated were almost nonexistent. Even though there is an office with a veterinary nurse, that office was more involved in vaccination programs and not on activities on pasture management, animal feeding, and so forth. Consequently, TUSIP technologies were new for the farmers in the area where the project operated. The pilot farm operators and other livestock farmers interviewed confirmed that there has been a lack of an innovation system for the livestock sector in the target area of the project. Also, TUSIP staff faced a lack of seed materials for improved species and a lack of knowledge at the local level.

   (b) The work was performed in relatively small areas (from 0.9 to 4.4 ha) on the family pilot farms and in a larger area in the community farm (about 10 of the 32 ha) where there were testing and demonstration plots. The project covered the costs of labor and part of the materials required for fencing and for forage seeds, while farmers provided the timber used to make the poles and covered other miscellaneous costs. The project did not request pilot farm operators to cover the labor costs for fencing, weeding, or planting because those activities were used as a learning opportunity for other workers and TUSIP needed the work completed in a short period. Replication of the areas intervened by the project was done completely by farm families. Construction of the corral and herdsmen's houses in the family farms were completely paid for by the farm owners. One exception was on the community farm, where the constructions of the herdsman's house and annexes for the community farm were completely paid with project funds, although labor was provided by the community. The idea for the latter was that the community farm would be used as a research and training unit for the whole community and for neighboring villages.

   (c) The fencing did not cover all of the farmland, only the areas intervened by the project. The initial purpose was to prevent animals from getting into pastures when they were under rehabilitation. Those fences will also serve to establish planned rotational grazing systems to prevent pasture degradation after the rehabilitated pastures enter the regular grazing management regime.

2. ***Related to the subsidy question, the project seems to indicate that payment for environmental services (PES) is needed to make it financially attractive. Is credit alone not enough? In several places the absence of capital is mentioned as the main constraint.***

   Baseline surveys (at the household and quarter level) conducted at the beginning of the project included a question related to the use of credit by farmers in the project community. All farmers indicated that they did not use credit. Most villagers saved money every week through the traditional savings system organized at the quarter level, but the amounts managed were small. While the project was running, a bank institution approached the villagers to gather

information needed to decide whether they should open a branch there, but project staff did not know if the bank subsequently established a branch or a system in the village. There are banks in Bamenda, which is about 50 km away, but none of the farmers were using any bank services. Considering the high cost of installing some of the innovations (such as fencing, as mentioned in the report), TUSIP staff proposed provision of a subsidy to promote adoption of technology innovations due to the strong potential for rehabilitated pasture to prevent and reduce negative impacts on the environment.

3. ***Is PES included in the follow-up proposal, and with the experience of the 22 months and the simulations, could the report give indications on the form (at start, for a couple of years, continuously, in kind or cash, up front or after the service has been delivered) of the level of subsidy?***

   PES is proposed as one of the components of the follow-up proposal as a means of speeding up the adoption of TUSIP technologies, recognizing the advantages for the environment after those innovations are implemented. In the report, the type and level of subsidy were not discussed much, but based on the experience of TUSIP, the suggestion was to contribute 50 percent of the fence installation costs in kind, basically providing barbed wire (the highest-cost item) to ensure that good-quality materials are used. TUSIP staff found cheaper wire in the market, but it would not last long. Several details about the qualification of applicants and monitoring procedures and other requirements need to be elaborated, but previous experiences in other World Bank– and GEF-funded projects could be drawn upon. In the second phase of the project, it should be possible to develop participatory farm plans with farmers and make arrangements where subsidies or PES are made to farmers based on agreements on land-use changes or fulfillment of good management practices.

4. ***The report describes a number of indirect impacts of the projects, without any quantification. Examples include that statements that "many people in Tugi village have started fodder banks in small areas to feed their animals," "many of them picked a job with the project," and "many of them started to save some money. . . ." In a scientific report such as this, some more quantification is desirable.***

   According to the information gathered, at least three farmers started replicating the rehabilitation strategies promoted by TUSIP. In all cases, these interventions were not larger than 2 ha, but keep in mind that these were "early adopters," with more resources than the rest of villagers who wanted to test almost in parallel what the project was doing. As is well known from other experiences, there is a lag time for accelerated adoption, and it will be facilitated once actual productivity results are reported. Also, there were nine women's groups (each with an average of 25 members) that participated in the TUSIP Gender Mainstreaming Component. The women groups started grazing and fodder bank areas in preparation for receiving sheep.

   Regarding the number of people who worked for the project on a temporary basis, staff prepared a role for all interested to participate on a rotational basis and to get payment in a more equitable way. On average, there were 20 workers participating regularly, and 10 to 12 of those saved an average of FCFA 10,000 per month (approximately USD 20 per month). It should be noted that about 10 of the workers who had left the village came back when the project started, and they were still in the village at the close of the project. It is difficult to project how many people could be employed by farmers in the new project because it will depend on the number of hectares rehabilitated, but if each farmer rehabilitated five ha, the equivalent of three to four full-time workers would be required on average for the whole rehabilitation process (including weed control, oversowing, and fencing). The idea is to have teams of 8 workers covering more than one farm, and it should be highlighted that TUSIP has already trained more than 20 people who could do such work.

5. ***The use of the LIFE-SIM model is interesting (and at least gives some interesting figures on methane emission), but how reliable is the model under the Cameroonian conditions?***

   The LIFE-SIM model was initially developed by CIP with data obtained in the Andean region of South America, but later, with the collaboration of ILRI and CATIE, the model was adapted and tested for other regions such as Southeast Asia, China, Kenya, the Caribbean, and Central America. It is true that the model has never been tested with the predominant cattle genotypes found in Cameroon, but estimation of the "baseline scenario" using the

data for degraded pastures resulted in an almost accurate estimate of the number of years farmers reported it takes to bring animals to market weight. Consequently, TUSIP staff felt more comfortable with the model and ran other scenarios (such as rehabilitated pastures with and without complementary feed obtained in the fodder banks). The model was run using the "criollo" genotypes of South America as a reference.

6. ***How was the reaction of the Fulani to the fencing and this technology? As discussed earlier, the fencing might interfere with their migratory livestock system.***

   The Fulani participated in a demonstration and learning session about fence construction, but no fences have yet been built on their lands. In the session, it was stressed that pasture rehabilitation, along with other intensification practices, should result in enough forage availability even during the dry season (when part of the herd is usually moved to other areas) to keep the family together at the family compound for the whole year. Fulani people are used to moving their animals on certain routes, either to the market or to pastures where the animals are maintained during critical periods, and fencing could effectively create conflicts if this interferes with their free movement. However, problems could be prevented by designing pasture fencing in a way that leaves corridors for animal movement. This could also be facilitated if the Village King (the fon), recognized by the natives and Fulani as the local authority, promoted meetings between farm operators and Fulani family heads. If livestock farmers from different villages are involved, the local authorities of both villages could join to promote this dialogue.

7. ***The reports indicate that fodder banks exist in the village but are not used because the fodder is too old. What assurances are there that the same will not happen with the fodder banks established under the project?***

   Two fodder banks in Tugi and one in a neighboring village (Tuochup-Chup) were not being used and therefore served as the source of planting materials. Several reasons were given for why they were not under use: one farmer reported that after his animals were stolen, he was too discouraged to buy new animals, and therefore he was not using the fodder bank; another farmer reported that his animals did not eat much fodder. These types of problems have been observed in many places; often farmers are impressed by the height and yield of the grasses present in a fodder bank but have not been advised on their proper management. In the participatory learning sessions and informal discussions with farm operators and workers, TUSIP staff emphasized that fodder banks require special management measures (that is, frequent use, application of manure, and chopping either by machine or with a cutlass to make fodder accessible for animals to eat). Thus, the fodder bank technology can be seen not only as introducing and planting a new species, but it also requires management and investment for proper utilization depending on the number of animals to be fed. Fodder banks were discussed as a strategic complement to forages obtained under grazing, not to be used for all animals, but for the animals whose owners invest in such technology. Successful use of fodder bank technologies depends on other conditions also, such as access to markets and prices for improved cattle quality, removal of barriers such as cattle rustling, incentives to invest in chopping machines, and so forth.

8. ***One technical question: Are five lines of fencing required?***

   The reason for having five lines of barbed wire in the fences is that small ruminants (mostly goats and sheep) were grazing in the pastures around the intervened areas and many farmers were observed practicing mixed grazing systems (although cattle constitute the majority of animals in the grazing groups). The distance between barbed wire lines was shorter in the first three lines to prevent sheep and dwarf goats from going through, while the last two lines had a longer distance between them. If there are only cattle in the grazing groups, TUSIP recommends having only four wire lines in the fences.

II. COMMENTS BY THE WORLD BANK'S EUROPE AND CENTRAL ASIA SENIOR LIVESTOCK SPECIALIST

1. ***The work to date seems very research oriented and the results are useful. Will the follow-on project be more of the same or move more toward scaling up in a practical way to promote adoption of what has been demonstrated would work.***

   Before TUSIP started, project staff did not have information on the level of pasture degradation that prevails in the Gutah Hills, so they decided to check if the scale used in Central America would work and

found it a practical tool for such a purpose. The staff also determined that the experiences developed for Central America—at a similar latitude and elevation to that of Tugi—on pasture rehabilitation strategies and other technology innovations could be adapted to the project target area. The new project will be oriented to promote the adoption of what worked in TUSIP, but it should be recognized that 22 months is too short to effectively assess most pasture and cattle technology interventions. Therefore, the new project will be built on the experiences developed here (including the outputs of the simulation model), but other best-bet interventions will also need to be tested on a limited scale before scaling up. In summary, the new project should emphasize promotion of interventions that were proven to work, but some effort will need to be devoted to evaluating other interventions that could not be tested under TUSIP.

2. ***Will market drivers and processors be involved in the next phase and will market considerations be integrated?***

   Several projects demonstrated that market opportunities are effective drivers of technology innovation; therefore, market considerations will be an integral part of the new project. Moreover, given the conditions under which TUSIP worked, most efforts were devoted to primary production, and estimates of changes in animal productivity were obtained through modeling. In the new project, secondary production will be directly assessed, but emphasis will also be placed on how to add value to livestock production. Improvements for the local cattle market and for dry meat processing are proposed for the new project. Other aspects considered for the new project are strengthening farmers' organizations, applying the value-chain approach to add value, and marketing in clusters to negotiate better prices.

3. ***The breeding program proposed should be explored to improve efficiency and production with gradual increase of appropriate improved genetics through AI or X-bred bulls as proposed.***

   TUSIP participating farmers and local leaders expressed interest in producing milk; however, the conditions found on the farms and the limited market access suggest that several steps have to be taken before getting involved in milk production. The Fulani women have limited experience milking their cows; it is done mostly in the first three months after calving, and the milk is used only for family consumption. The Meta people in Tugi do not have experience producing milk, and their animals have limited milk production potential. Based on this, TUSIP suggested getting crossbred (local breeds crossed with European dairy breeds) bulls to serve their cows to produce heifers with better milk production potential in the future. Among the available local breeds, the Red Fulani and Gudali cows were suggested for crossing, as phenotypically these are the ones with more favorable dairy characteristics. This process will take time but could be accelerated by purchasing crossbred females if available in the market. However, regardless of the option chosen by Tugi farmers, there is a need for them to be trained on milk production, as the activity will be new for all. An option not encouraged at this time is to bring dairy cows like the ones promoted by the HPI because present conditions on the farms are not conducive for adequate milk production performance and access to markets is limited by poor road conditions. Although the use of artificial insemination could allow farmers to use better-quality bulls, it is not a viable option at this time, as farmers need to first move to more intensive management to facilitate heat detection and improved feeding systems.

4. ***The production system might also be improved if, as suggested in the text, heifers are first calving at 4 years of age and cattle reach market weight at (400 to 500 kg) at 7 years of age. Is this correct or am I missing something? The objective of reducing age to market to 5 years hardly seems profitable in any livestock model, and the analysis then calculates IRR based on 200 to 400 kg BW. Please review the information for consistency in terms of age to market weight and IRR calculations. It seems the best we can expect for age to market weight is 3.6 years based on table 9.2. Is that just on grass or does it include a confined fattening period? Age at first calving, calving intervals, and days or months to market all seem to be potential areas for significant improvement and benefit to producers and should improve with better feeds and grazing, but this is not referred to or analyzed.***

   None of the TUSIP participating farmers or the ones considered as control farmers have any record keeping systems for cattle production or reproduction; therefore, the figures cited (four years old at first calving and seven years to reach market weight) are

the result of estimates given by those interviewed. In the simulation model, target weight scenarios of 400 and 500 kg BW were used. Actually, 400 kg could be the best slaughtering weight based on the conformation of those animals. In terms of feeding strategies, only those based in pastures were considered (either rehabilitated pastures managed under grazing or the same plus supplementation with cut-and-carry forages). Indirect observations, such as the cow/calf ratio in the herd composition, suggested that fertility is a constraint in the system, attributed to the fact that soils in the area are poor in phosphorus, pasture availability is limited (particularly during the rainy season), and farmers do not provide mineral mixtures to the animals. Based on those factors, TUSIP recommended including in the FFS curricula a session on mineral supplementation using multinutrient blocks, with a corresponding simple participatory experimentation exercise. This could not be implemented while the project operated, but is expected to be part of the new project learning sessions, as a strong impact on accelerating animal growth and reproductive performance is anticipated. Scenarios involving supplementation with concentrates were not considered because farmers only use those for pigs. The use of supplements could be a further step in intensification, as it would significantly reduce time to get to the market weight, but at this stage, the focus was more on understanding the potential of an almost self-sufficient system, with very limited use of external inputs. If farmers produce more fodder trees on their farms, those could provide some supplementary protein or the farmers would basically be requiring some cheap energy source for a supplement.

5. ***If dairy is a potential area of improvement, I would like to see more data on the milk production and demonstration of potential improvement such as table 9.2 including yield data, calving intervals, and so forth.***

   Potential responses to the technology interventions proposed by TUSIP were simulated using only the beef cattle routine of the LIFE-SIM model because that is the only option practiced so far by farmers in the Gutah Hills. The model also has a routine for predicting milk production with dual-purpose cows, but this scenario was not estimated as there are no local data on the potential of the proposed milk production system using crossbred animals such as the ones suggested by TUSIP. After the technical advisor left the country, three dairy herds were visited by project staff and farmers; two of those were the source of the crossbred animals bought by the project. Those herds need to be evaluated for the level of milk production obtained per lactation to choose the appropriate equations to run the LIFE-SIM model that will assess the potential responses to the proposed technology interventions in terms of milk production, live weight change of cows during the lactation period, and expected effects on reproduction. This work should be done at the beginning of the new project, as village authorities and many farmers expressed interest in shifting gradually into milk production systems.

6. ***Has the team given any consideration to cooperation with Heifer Project International (HPI), which also operates in Cameroon? We are in contact with them on other projects if there is any interest and you may be able to leverage some of their funding. The proposal to scale up TUSIP is similar to the work HPI is currently undertaking in Cameroon***

   The HPI-Cameroon offices were visited by TUSIP staff, and HPI's staff were invited to participate in some of the meetings organized by TUSIP, but there was not the same level of response as that obtained from ICRAF or ILRI. For cattle activities, HPI's main efforts are in smallholder peri-urban dairy production in the NWR of Cameroon, relatively not far (about 2 hours) from the TUSIP site, and their main office is located in the same city as the Akwi Memorial Foundation office. Once the new TUSIP project moves toward milk production, it should establish more effective collaboration with HPI.

7. ***In terms of the grazing management systems, I am not knowledgeable of the situation in Cameroon, but it would seem to me that there is some opportunity to combine the paddock fencing with some form of community-based pasture management as is being done in other countries as a transitional strategy until the more sedentary fence-based approach to pasture management can be invested in. Is this being considered?***

   TUSIP fully agrees with the observation. It is not possible (at least in the mid-term) to convert the whole area currently managed in an extensive grazing system into one based on the use of paddock fencing for two reasons: (1) high investment costs

for transforming the prevalent grazing system in the Gutah Hills and (2) most grazers are using the government's land based on a grazing permit so they will not invest in an area they do not own. For TUSIP staff, fencing is at first a tool for excluding animals from a pasture that is subject to rehabilitation. Although it is a challenging task, the same could be done in areas grazed with a herdsman, but as indicated before, herdsmen need to be trained because currently most of them follow the animals rather than guiding them to a given grazing area; that is why grazer and farmer conflicts frequently erupt. The principles of controlled rotational grazing need to be shared with herdsmen under the FFS approach, as proposed in the new project. In those farms where pastures are owned by families, a transitional change from free grazing to a fence-based rotational grazing system is foreseen.

8. ***The pasture pilot diagrams do not reflect watering points, and their placement is usually the main limiting factor in such a system unless the plots are all so small that the one point is sufficient. Figure 5.9 is more conducive to a cost-effective common watering point that provides continuous access rather than the arrangement in figure 5.11, but the water access is not illustrated.***

   Establishing watering points is one of the interventions promoted by TUSIP, even though that is not explicitly indicated in the paddock diagrams in the report. There are two reasons behind the intervention: (1) to reduce water pollution and (2) to prevent damage in the riparian forest when animals drink directly from streams. TUSIP evaluated water quality at 23 points where the Tugi population gets water, and found that 50 percent of the water sources were contaminated and hence unsuitable for drinking. A water distribution system using gravity was strategically designed for paddocks and corrals where animals could be maintained.

9. ***The pasture health measurements based on plant species seem to be somewhat complicated for herders or farmers to evaluate on a day-to-day basis to make grazing decisions, based on experience we had elsewhere. Are there rotational grazing plans developed along with the fencing that provide timing for rotation that includes open pastures?***

   The method reported is for the assessment of pasture degradation status as a basis for deciding which pasture rehabilitation strategies need to be applied, not for making decisions on grazing management (that is, when to put or take out animals from a given paddock). The proposed system for assessing pasture degradation is based on visual observations and therefore does not require the use of any pasture management devices. As it uses visual estimates of the contribution of different pasture components as a percentage, it cannot be used by illiterate farmers (as were many of the partner farmers in TUSIP). However, in a similar situation in Northern Guatemala, the method was applied successfully. It should be noted that several of the groups there were from the indigenous population, so facilitators adapted the session guidelines to local languages; this would also be the case in the Gutah Hills. In the Northern Guatemala cases, the strategy was to hold two participatory learning sessions with farmers. The first focused on their perceptions of pasture degradation, the criteria they use to identify levels of degradation, and the measures they would take to rehabilitate pastures. The second was a practical session to evaluate pastures previously chosen as representative of different levels of degradation according to technicians' standards; farmers ranked pastures in the same order that the technicians did but using their own criteria.

   TUSIP did not have a learning session on when to move animals out of a paddock but discussed the use of estimated residual forage availability as the criterion based on the height of the residue of some indicator species (the edible ones), but these concepts need more elaboration with project staff and farmers.

10. ***In terms of grasses and legumes, ILRI seems to be involved and have experience. In other parts of Africa, they have tried Napier blended and intercropped with leguminous grasses with some success. Is this being considered? Does it seem to be a focus on Guatemala grass?***

    TUSIP staff looked for forages to be used in the fodder banks, and Napier grass was one of the first choices, knowing there were some accessions native to Cameroon. At the time, it was necessary to first establish the fodder banks, and a reliable source of a high-yielding accession could not be found in sufficient amounts. That was the reason for starting

with Guatemala grass, a species already introduced in the village. There was a long discussion about which legume to introduce in the fodder bank, and the first choice was *Acacia angustissima*, a fodder tree for which enough seeds had been produced by a group of farmers trained by ICRAF in a village about two and a half hours away from Tugi. The goal was to introduce the concept of grass and legume mixtures for fodder banks, but the components could change based on the availability of seeds or planting materials. In fact, TUSIP's contacts in ILRI were asked to provide some seeds of best-bet options for the prevalent agro-ecological conditions in Tugi, and those were initially planted in the tree nursery. In the second phase of the project, the plan is to allocate more resources for developing a wider collection of potential tree and shrub species using Central America and African experiences.

11. ***Have all of the capital investment costs described been incorporated into the IRR calculations, including the cost of herbicide application?***

    Yes, all capital investments were included in the IRR calculations. The costs of herbicides and labor required for their application were not included because the specific herbicide for controlling the bracken fern was obtained late and tested only in small areas. Therefore, it was assumed that weed control was done by hand, in all rehabilitated pastures, as there were good estimates of the labor needs for that activity.

III. COMMENTS BY WORLD BANK'S AFRICA LIVESTOCK SPECIALIST

1. ***My major concern about this final report is that it is very inputs-oriented. It describes well what has been done, trainings organized, technologies demonstrated, and so forth, but lists very few results. Again, I was not expecting the authors to give us detailed analysis of the outcomes of the project and how successful it was, given the short period, but the document should submit to us an in-depth discussion on how this project could be assessed in terms of impact and could be considered as successful or not—what could be outcome indicators, how do we measure them, what would be target values for these indicators that would make the project successful, when to undertake an in-depth impact evaluation of the project, what could be the methodology for this impact evaluation, and so on.***

   As the reviewer comments, the report does not propose a methodology for evaluating the impacts. To do so requires first considering the baseline scenario before the project started and the indicators that would be used to measure the baseline. This would include the following:

   - Farmers in Tugi had local knowledge on the existing farming conditions, but they did not have practical knowledge on how to rehabilitate degraded pastures or how to implement improved feeding technologies. One of the major impacts of TUSIP was changing farmers' skills and knowledge to improve management of the current systems by using the FFS approach; this is a measurable outcome.
   - Farmers had the perception that pastures were not producing properly because of the degradation status, but there was no information on the state of degradation of those pastures or on the economic, social, and environmental impacts. TUSIP evaluated these factors, which are key for decision making.
   - The baseline scenario showed that there was no technology innovation in the project area; thus, the project can be evaluated in terms of how many farms implemented improved technologies. In fact, the project document proposed work on five pilot farms, and the project staff, along with the farm operators, did indeed implement technology innovations on all five farms. Tugi Village is a good example of an area characterized by subsistence systems and a very poor population; this project outlined the stages required to transition such an area into market-based production systems to ultimately improve livelihoods: (1) training, (2) organization of farmers, (3) investment in improved technologies, (4) development of markets, and (5) institutional services, such as those related to technology transfer.

2. ***Without this, I do not see how the document can discuss replication potential and fulfill its specific objective of proposing a means to scale up the project to other communities. As indicated in the economic feasibility of the proposed interventions, the IRR and the changes in net incomes are not necessarily excellent without important subsidies. So one should be careful before advocating for a scale-up of the initiative without a clear idea on how the medium-term impact of the project will be***

assessed. This impact assessment will have to be done in the future, and we should think of securing funds for this.

Experiences in Latin America and elsewhere have shown that lack of capital for initial investments in technologies is a major barrier for their adoption. However, studies on projects managed by the World Bank have shown that PES is an incentive that promotes adoption of silvopastoral technologies. Other studies indicated that implementation of green credit schemes also resulted in greater adoption of these technologies, so those experiences can be used to develop an incentive system for Tugi Village. It is possible that there may have been some overestimation of costs because of the small scale of the pilot project; on a more commercial basis or a larger project, costs might be reduced.

3. ***(a). When reading the document, I was really questioning the productivity parameters used by the project. They might be good for Costa Rica's production systems, but are they adapted to the agro-pastoral production systems of North West Cameroon? I am not sure about this, and this could be a reason why the baseline survey was a failure in terms of collecting data on productivity as described in the report. When looking at table 9.2, my first question was whether these parameters/indicators are measurable in the Gutah Hills–specific context. For most of them, this is probably not the case, and working on live weight gain in pastoral context is often difficult. The stocking rate is also something highly questionable and totally dependent of herd and pasture management (the document recommends the use of a holistic approach, which is good, but does not give any further details on it). Then, to calculate the benefits generated by the zootechnic parameters chosen by the project, I believe that the authors considered that the production system is market oriented, with fattened animals sold rapidly. This is absolutely not the case in these production systems (because of traditions and lack of infrastructures for it), where often, the number of animals is of highest importance for the producers and they prefer increasing the size of their herd when pasture is good than immediately selling nonproductive animals (such as males that have stopped growing). Intervals between births, fertility rates, milk production (Fulani are producing milk if I remember correctly) are often easier to monitor. Moreover, the economic analysis must then be done based on the herd evolution using zootechnic models such as Lesnoff. The result is that the economic feasibility described in the report is probably very optimistic, as producers do not easily sell their animals, so the income generated is not immediate.***

The tendency to keep as many animals as possible is a common decision made by many farmers that are not fully market oriented, not only in Africa, but in Latin America and Asia as well, because herd size is a determinant of status. However, some sort of intensification in livestock farms is needed for those systems to contribute to improving the livelihood of rural families. Moreover, keeping as many animals as possible, with no interventions to rehabilitate degraded pastures, only exacerbates the existing environmental problems. Regarding market opportunities, in the village where TUSIP was based, there is a very active cattle market that operates once a week, and even though some animals are sold locally, most animals are bought by middlemen who take animals to larger markets elsewhere in the country (Bamenda, Yaoundé, and Douala) and even for export to Gabon, Central African Republic, and Equatorial Guinea. Also, there is some processing in the village (one to two animals every week) of dry (smoked) meat to take to the Central and Southern provinces of Cameroon. Therefore, demand is not a limiting factor. Trading conditions are not optimal in the local market, so TUSIP proposed some changes in the local market operation that should make cattle negotiations more attractive to producers. TUSIP fully agrees that resources are needed to better monitor changes in dairy operations, especially as livestock farmers in Tugi are interested in moving into dairy production. However, this will take time because farmers need to be trained on milk production and the current stock of animals has very limited milk production potential. The project started efforts to introduce crossbred animals to improve the milk production potential in the area using the two local breeds (Red Fulani and Guhdali) that, based on appearance and local knowledge, seem to have the greatest milk production potential. Such pursuits will be further emphasized in the new TUSIP project.

(b). The percent of reduction of live weight gain mentioned in the report, using the Costa Rica

model, seems risky to replicate in Cameroon context. This parameter is highly dependent on other factors (such as health and husbandry practices), but specifically of the breed. Local breeds are well adapted to Gutah Hills environment, and it is unknown why these percentages are so high in Cameroon when the pasture condition is getting worse.

It is assumed that this comment refers to the data included in tables 9.2 and 9.3, with values generated using the LIFE-SIM simulation model. It is correct that the model has not been validated with data for Cameroonian breeds because information on growth rate and milk production for the most common local breeds (White Fulani, Red Mbororo/Fulani, and Guhdali) was not available and the project did not run long enough to generate it. However, some clarifications can be provided with respect to the model used for the TUSIP scenarios. LIFE-SIM was initially developed by the International Potato Center (CIP) using information from the Andean region of South America and covered agro-ecological conditions similar to the ones in the NWR of Cameroon. Later, in collaboration with ILRI, efforts were made to adapt and test the model under the prevalent conditions in Southeast Asia and Southwestern China. CATIE also collaborated in adapting and testing the model to the conditions of Central America, and CIP tested the dairy subroutine of the model in Kenya. In all cases, the predictions did not differ significantly from direct animal response measurements found in controlled experiments. Another advantage of LIFE-SIM is that the information on feeds required by the model can be easily generated in developing countries. Most algorithms of the model are based on equations provided by the National Research Council of the United States, which, along with the British ARC system, are the most widely used equations by nutritionists, not only in those countries, but in the tropics as well. LIFE-SIM's estimated time required to reach market weight was very close to the information provided by local farmers, although those are rough estimates as Tugi farmers do not have any written records related to production of their animals. Finally, while the absolute estimates produced by the model might not be reproduced in reality, TUSIP has a high degree of confidence that the relative rankings of the model will be consistent with reality.

4. ***It is the same when comparing changes in net income between degraded versus rehabilitated pastures in figures 9.1, 9.2, and 9.3. The authors pointed a negative net income for degraded pastures, but with the assumption that full vaccination, deworming, and mineral supplementation are happening. This is not the case in these areas, where a very low input and output system is practiced. I am not sure that the net income of this system would be negative.***

   The rationale used by the owners of small- and medium-sized farms (who do not use credit and do not have records) to analyze the economics of their farm operations is not the same as that applied in a traditional cost-benefit analysis. Most farmers in the Gutah Hills practice regular deworming and mineral supplementation of their animals, although supplementation with common salt is not a practice regularly used. Vaccination is applied by almost all farmers, as it is a government service. The cost of all three practices is minimal compared to other items, even in these very low input and output systems. Livestock farmers usually do not include the cost of labor and management when analyzing the economics of their systems; these items are included in the analysis in the report and are probably the source of the slightly negative net income values. Also, the economic analysis presented in the report considered only one part of the whole enterprise (live weight gain for young males from 200 up to 400 or 500 kg), not taking into account other components that contribute to farm and household economics, such as reproductive efficiency and mortality in cattle, small ruminants, and crop production, as well as income generated off the farm.

5. ***Table 5.7 would be more informative if the comparison was done at the same period of the year. It is difficult to compare vegetation cover in degraded pastures at the end of the dry season (March) with rehabilitated pastures assessed in the rainy season (June) and to conclude that the project was successful in increasing the proportion of edible grass and legumes.***

   TUSIP fully agrees with the comment on the effects of season on pasture composition. However, even though the same methodology was not applied along the whole rehabilitation process, visual estimates were used to monitor the changes in botanical composition and soil cover over the whole year and to

make decisions. For example, the presence of bracken fern increased markedly after the rains started, so two additional hand weedings were applied until TUSIP staff felt confident that this noxious weed was under control. A similar evaluation is proposed for the following dry season (early 2012) after the pastures have been used for at least three grazing cycles, but informal observations confirm that to date, favorable changes in vegetation cover have occurred.

6. ***Is Guatemala Grass already present in Cameroon? Has the risk of introducing exotic plant species in Gutah Hills been well assessed?***

   Guatemala grass is not a species introduced by TUSIP. Even though its common name refers to a Central American species, it was the only cut-and-carry grass already planted in Tugi Village. Other sources of cut-and-carry grasses, such as Napier grass, were sought, but the accessions found, mainly on roadsides, did not respond to expectations, and staff could not ensure that they were genetically uniform. For that reason, other grasses and legumes deemed the best-bet options based on the prevalent agro-ecological conditions were obtained from the ILRI Forage Germplasm bank. However, the quantities of seeds and planting materials received for each accession were minimal and were planted in the nursery to multiply before transplant in the field.

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