



**Royal Tropical Institute**



## **The USISS Enterprise**

**A case study on the costs and benefits of solar-dried produce in Mali, including market opportunities and constraints**

**United Nations Environmental Programme**

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## Introduction

USISS is a small solar drying enterprise in Mali that produces sun-dried mango and sun-dried meat. Early 2008 it has been studied as a case in a wider initiative by United Nations Environmental Programme with the financial support of the government of Norway to assess and promote the contribution that sustainable consumption and production could make to poverty alleviation in developing countries. Sustainable consumption and production is in this context considered as: "the production and use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the ability to meet the needs of future generations" (Norwegian Ministry of Environment, Oslo Symposium, 1994).

The initiative aims to contribute to the achievement of the millennium development goals through more efficient resource allocation, identifying the barriers to investment in sustainable consumption and production at national and local levels in developing countries. To this end an analysis of relevant available information has been started, including the outcomes of case studies, each consisting of:

- a cost-benefit analysis, highlighting the socio-economic and environmental costs and benefits (both quantitative and qualitative) linked to the product throughout its life cycle;
- a market assessment on existing and potential local, regional and/or international markets for the sustainable product under review analyzing scalability and risks involved.

The results of the case studies feed into an overall guidance document presently in preparation on analysing 'sustainable ventures' - businesses and other micro-level activities that are profitable and contribute to human well-being as well as environmental sustainability.

The present report reflects the results of the case study in Mali on the earlier mentioned solar drying enterprise USISS. The company has been supported in the framework of the African Rural Energy Enterprise Development-initiative (AREED), a partnership of UNEP, E+Co (Energy Investment Service) and five country partners, offering sustainable energy entrepreneurs in the five countries, including Mali, a combination of enterprise development and start-up loans.

In the report evidence is presented on whether and if so, how the USISS solar drying business contributed to poverty alleviation. To this end a detailed assessment of socio-economic and environmental costs and benefits is made, taking into account the life-cycle of the dried products. The report also reflects the results of a market study, identifying existing as well as potential new local, regional and/or international markets for sun dried mango and meat and barriers to these markets.

The authors wish to express their gratitude to all who have kindly contributed to the study, in particular to Mr Mamadou Doumbia, Director of USISS for his kind collaboration, to Mr Tim Poudiougou, Mr Modibo Traoré and Mr Michiel Arnoldus for their contributions to the market study, to Mr Modibo Traoré and HELVETAS for providing data on their mango drying activities and to the staff of the two NGO's (MaliFolkecenter and E+Co) involved in supporting USISS. Furthermore, the contributions of the team involved in preparing the overall guidance document are highly acknowledged, in particular those of Christina Gradl, Aline Krämer from EMERGIA and Esther Reilink from UNEP.

## 1. The USISS enterprise

USISS (Usine Semi-Industrielle de Séchage Solaire) is a small enterprise in the capital of Mali, Bamako, drying meat and mango for the local market, mainly the market in Bamako. With a yearly production of around 2000 kg of dried meat and 400 kg of dried mango, its yearly revenues amount to around 58,000 US\$. Presently there are five permanent employees who are equal owners of the company and together decide how profits are distributed. The enterprise does not have shareholders.

USISS has the legal status of a GIE (Economic Grouping of Interest). GIE's are small for-profit companies that receive tax breaks due to their size<sup>1</sup>.

### 1.1 History

The enterprise started in 1990, after completion of a project from GTZ (German Technical Development Agency) to test the viability of solar powered food dryers GTZ had transferred a solar dryer to Bamako that was tested for drying of shallot chips in the Dogon area in Mali but was considered as 'too sophisticated' for use in that area. Before the project ended, the project team completed a feasibility study to determine whether the project could continue as a viable business. The results of the study were favourable and the project manager of the time agreed to purchase the dryers for a small fee and to continue the operation on a commercial basis.

Since 1990, USISS has been successfully selling dried meat, mango and onion in Bamako using the technology introduced by GTZ. In 2002, through the African Rural Energy Enterprise Development-initiative (AREED), USISS applied successfully for a loan of FCFA 12,747,600 (US\$18,200) to scale-up operations. The loan would be spent to buy new equipment (64%) and to provide working capital (36%). It was expected that the loan would triple USISS's production capacity.

In 2005, the founder and director withdrew from USISS. He was replaced by the current director.

### 1.2 Main activities

The principal activity is the drying of meat for snacks. Fresh meat is bought at the principal market in Bamako with a specific wholesaler, sliced thinly, seasoned and then dried for about three days in the solar dryer. After drying it is packed in 50 gram bags and sold mostly to small supermarkets, but also to traders or groups distributing through ambulant vendors and other collective buyers such as the military camp in Bamako.

As a second activity in the mango season (from April through July), mango is bought mainly from locations near Bamako (Siby, Baguineda). After peeling and slicing, it is dried for about two days in the solar dryer. The dried mango is packed in 50 gram plastic bags and sold as a snack in a similar way as the dried meat.

In the nineties, shallot was bought in the Dogon area (700 km NE of Bamako), which is the principal area for shallot growing, and sliced and dried. Since the technology of slicing and drying (in the open field) was heavily promoted by donors and NGO's, USISS could not compete and abandoned shallot drying around the year 2000.

<sup>1</sup> Under the recent law orienting agriculture (Loi d'Orientation Agricole) a national fund is being established to ensure food security. Although it is especially meant to minimise impacts of risk and calamities on agricultural development, specific subventions could be given to cooperative organisations to reduce poverty and protect the environment. It is not clear if enterprises like USISS could be subsidized under this law. No specific subsidies exist for environmental friendly enterprises.

However, from 2000 to 2004 USISS continued trading of the dried produce from the Dogon area selling it with a reasonable margin. Some of the dried shallot chips were repacked in smaller plastic bags using the enterprises packing machine, but most were sold in the original wholesale bags. This stopped in 2005 when general sales of dried shallot chips went down and as a consequence producers sold their product to private traders under the official price fixed by the Dogon shallot producers association. As a result, USISS, having bought against the official price had to sell the dried shallot at a loss.

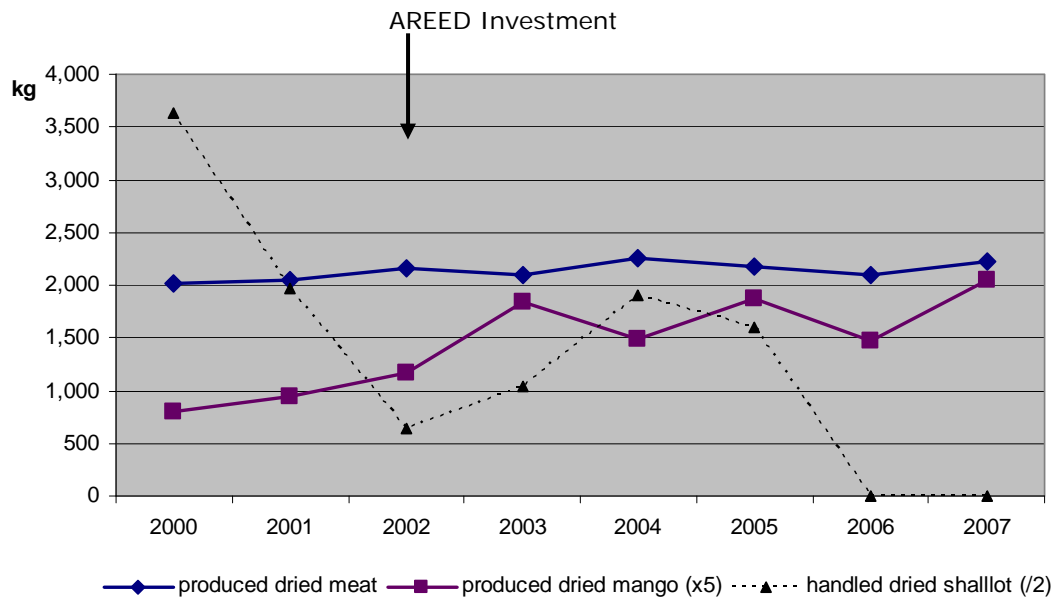
USISS staff is also engaged in jointly buying rice and millet (annually between 0.5 and 1.5 million FCFA, which is 1,200-3,500 US\$). These products are mainly sold to the individual USISS staff members, deducting the costs from their salaries.

In 2000, the enterprise bought a grocery (Sokorodji) in Bamako (total investment about 1.6 Million FCFA, 3700 US\$). These activities are not really connected with the drying enterprise, although there are some sales of dried meat and mango at the grocery.

### 1.3 Physical production data for 2000-2007

Throughout the 2000-2007 period, USISS produced and sold around 40-50,000 bags of dried meat and 4000-8000 bags of dried mango per year. The evolution over the period is presented in graph 1. For both products, variations in end-of-year stock are negligible, thus the production lines match the sales lines.

As indicated above, shallot was not dried in this period, but considerable quantities were handled. Detailed data on the production of USISS are presented in annex 2.



Graph 1. Sales of dried produce by USISS

Producing and selling dried meat is the principal and most stable activity of USISS. Volumes have slightly decreased in recent years, from around 2200 kg in 2004 to around 2000 kg/year, but due to price increases, the turnover is still increasing (see chapter 2). Production and sales of dried mango increased from around 160 kg in 2000 to 410 in 2007, which is a positive development because the margins on dried mango are higher than those on meat (see chapter 2).

The AREED loan in 2002 appears not to have had much impact on the production of USISS.

#### 1.4 Use and reimbursement of the AREED loan

The AREED loan of US\$ 18.200 obtained in 2002 was intended to triple USISS' production capacity by buying new equipment and providing working capital. Two factors support the impression that the loan has not really been used for that purpose (see details in annex 3):

- The equipment and material presently in use represent at most 23% of the loans value.
- The books reveal investments of around 16% of the value of the loan.

This means that the loan was spent mainly for other purposes, which could in principle have a higher remuneration than the solar drying. This would explain the lack of growth of production (see chapter 2) combined with the reimbursement of the loan, which was even higher than originally agreed upon (annex 3).

#### 1.5 Equipment and facilities

The initial equipment consisted of a tunnel type dryer built on the roof of a building in Bamako by the company Solar-Energy-Technik with a heat collector compartment and a dryer compartment. The system was 3 m wide and 20 m long. The heat collector and dryer were arranged in parallel. Due to the high pressure drop in the U-turn between the heat collector and the dryer, it was not possible to equip the system with a photovoltaic drive. This is the main reason why nowadays collector and dryer are normally arranged in series. As cover material a so called air bubble foil was used<sup>2</sup>. The system was directly installed on the ground, making loading and unloading rather uncomfortable and causing problems during heavy rains when water tends to enter the dryer.



Figure 1. Present director of USISS with the double solar tunnel dryer (drying racks against the wall of the handling room).

In 2002, the loan received through the AREED program was partially used to transform the single U-turn into two straight dryers, placed in parallel. An extra fan was installed and the old material was partly replaced with locally available metal profiles. New air bubble foil and green net for the drying racks had to be imported. The system remains directly installed on the ground with the associated disadvantages (see figure 1).

With this equipment USISS normally dries 200 kg of fresh meat in 3 days (max. capacity 400 kg fresh meat) or 200 kg of fresh mango in 2 days.

It should be noted that while solar drying would be a cost-effective way of drying in a hot and dry climate as in Mali, the technology is not yet well developed for the local conditions. Solar drying equipment is largely based on imported material and more expensive than needed if local material would have been used. Development of cheap

<sup>2</sup> This foil has a high mechanical strength and better heat isolation than the single layer poly-ethylene foil presently used by the German supplier of the dryer, with better transmission in the short wave range and thus more solar radiation striking the heat collector. However, the better isolation of the bubble foil could be an advantage in the cloudy conditions for mango drying in June and July, when loss of heat diminishes the inside temperature in the dryer.

semi-industrial drying equipment seems still in an amateur stage. Solar drying techniques also require adaptation for specific products, weather types, time of the day and season. USISS has been hardly assisted with knowledge on drying techniques and on equipment and its costs.

Besides the dryer, also on the roof of the building, a small working room is located where the products are peeled, sliced and packed after drying and where the administration is kept. For this, there is a wooden working table used for peeling, slicing and administration and packing equipment, a refrigerator and boxes to store the products (see figures 2-4).



Figure 2. Working room with table, refrigerator, cupboard and sealing equipment.



Figures 3,4 .  
Box for storing  
the dried  
product.





## 2 Costs benefit analysis for solar drying by USISS

To give an impression of the economic, social and environmental impacts of the enterprise, the costs and benefits in these three domains, often referred to as the people-planet-profit domains, were analysed. The analysis not only covers the enterprise itself, but also pertains to impacts downstream and upstream in the value chain, including an analysis of the impact of wastes.

### 2.1 Method used

The method used to assess the economic, social and environmental costs and benefits over the entire life cycle of the products dried by USISS has been described by Gradl et al. (2008, see figure 5). Various costs and benefits were identified using a two-stage process. At first, processes were identified that eventually could have important consequences for the CBA of the mentioned products. Some processes were estimated to be of less importance and were not taken into account (e.g. the production of herbs used for seasoning of the dried meat). The underlying estimations are based on experiences of the authors and on consultations with other experts. Secondly, more detailed analysis of costs and benefits was made for processes estimated to have important consequences for the final CBA.

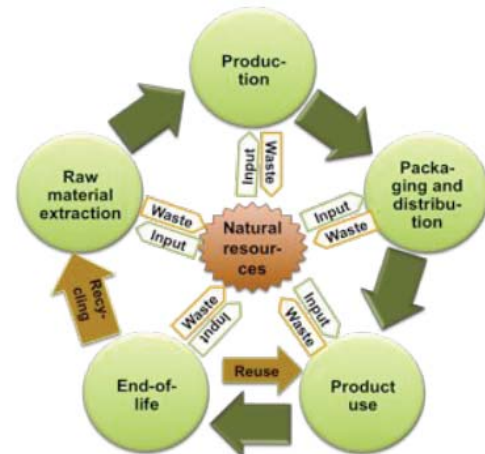


Figure 5. Lifecycle analysis as presented by Gradl et al. (2008).

#### 2.1.1 The life cycles of dried meat and mango

Economic, social and environmental costs and benefits were analysed along the life cycle of the two products, meat and mango:

- Most of the meat dried by USISS is produced through extensive herding on pastures in the less humid areas of the country. Cattle is transported on the hoof to a slaughterer in Bamako, where USISS buys it. Before drying, the meat is seasoned with (imported) salt and herbs bought at the market in Bamako, produced by local vegetable growers.
- Most of the mango dried by USISS is produced in orchards near Bamako. Hardly any inputs are used during production, but sometimes the orchards are sprayed against insects. Usually the producers leave the harvesting to trackers, coming on behalf of traders to select the mangoes they want to buy. Mangoes are transported mainly by truck to the three markets where USISS usually buys them. No other products are added before or after drying.

Packing is done in small polyethylene bags produced locally from imported granules. Waste during local production of the bags is low.

The dried and packed product is sold to supermarkets and distributors, who sell it to the clients (the distributors through ambulant sellers). After consumption the plastic bags remain and constitute a part of Bamako's city waste.

### *2.1.2 Direct and marginal analysis*

In general, two types of analysis were carried out:

- A direct analysis of impacts of USISS as an enterprise along value chains in the three domains mentioned above.
- The second analysis is a marginal analysis of costs and benefits of solar drying by USISS, comparing them with similar activities using conventional energy sources for drying. In this way the environmental benefits of solar drying, that are lost in the first analysis, become clear.

Results of both analyses can be used in the assessment of the effectiveness of policies stimulating sustainable consumption and production for poverty reduction and wealth creation, but should be applied with care in realistic scenarios. For example, the main environmental benefit of solar drying is that it avoids the use of fuel wood or gas for the drying process. Calculating the benefits of scaling up would then suppose that there exist already consumption of gas dried meat or mango at a larger scale level, which actually is not the case. Hence the application of one method or the other for CBA of up-scaling depends not only on market possibilities identified but also on what is the actual scale of the reference technology.

### *2.1.3 Environmental and social costs and benefits*

The environmental analysis concerns the environmental effects of USISS as an enterprise. It includes environmental costs due to mango and meat production (pesticide use on mango, overgrazing for meat production), transport of primary material, use of plastic for packing and transport of the dried product. Also, a marginal analysis was performed pertaining to the analysis of environmental advantages of solar drying by USISS. It includes the valued environmental benefits of mango and meat drying by the solar technology used by USISS compared to those using wood and propane gas for drying.

The social analysis concerns social effects of USISS. USISS is a small enterprise integrated completely in the Malian system and thus could be considered as stabilizing the current livelihood system rather than destabilizing it. In our view, this helps in maintaining social safety in the present cultural setting, where foreign, larger companies would possibly more likely contribute to uprooting actual social safety systems. We are aware that this view could be contested, taking into account that the present social safety system is far from ideal and that changes are required to improve it. With such a view, the USISS enterprise would stabilize the current status quo with its associated unequal distribution of income and power. This type of social CBA, based on subjective perceptions on what is positive or negative, was avoided as much as possible.

For the present study, along the value chain, a fraction of the value added is determined that provides labour and income for vulnerable groups. The calculated revenues for low income groups are then considered as social benefits generated through USISS. Increased access of vulnerable groups to knowledge, health and labour is evaluated qualitatively.

Environmental and social analysis is based on 2007 price data and thus describes the actual situation for USISS and not the historic evolution.

### 2.1.4 Scope of the analysis

The present analysis covers the solar drying activities of the enterprise. These are part of a range of activities undertaken by staff members including collective buying of rice and millet, the running of a grocery (Sokorodji), support of family members, the trading in dried shallots etc. In general, the non-drying activities are partly mixed in the USISS financial administration and their benefits are sometimes used to compensate losses on the drying activities. Yet these activities, frequently entailing private loans and repayments to individual staff members, are not included in the analysis as they are not really connected with the drying enterprise.

Details on data collection and reliability are presented in annex 1.

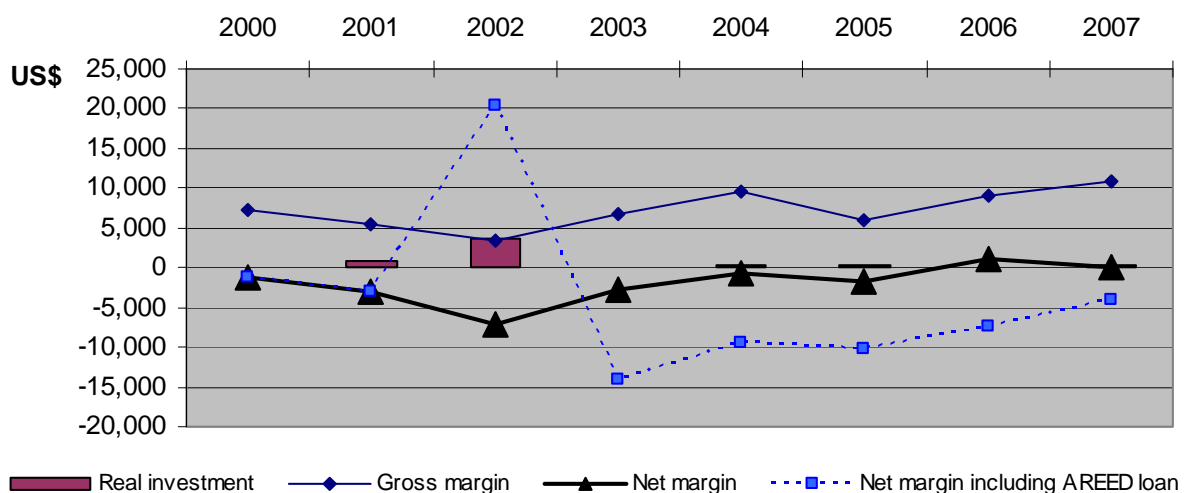
### 2.1.5 US\$ rate used

USISS is a Malian company working entirely for the market in Mali, thus using FCFA currency (West African Franc, XOF), which is pegged to the Euro (1 € = 655.97 FCFA). The best insight in costs and benefits of USISS and their historical trends would be in that local currency. Yet, as the present case study is part of a larger assignment within a UN project, the US\$ dollar rate has been chosen to express monetary values. One fixed US\$ rate has been applied: 430 FCFA/US\$, the exchange rate at the moment of the study (February 2008). Using historic conversion rates would disturb the actual analysis with the weakening of the US\$ with respect to the FCFA in the analysed period.

## 2.2 Economic cost-benefit analysis for the period 2000-2007

### 2.2.1 Direct economic costs and benefits for USISS

Evolution of costs and benefits of solar drying by the USISS enterprise is represented in graph 2. Detailed data are included in annex 4.



Graph 2. Evolution of margins of solar drying by USISS.

The gross margin fluctuates between US\$ 5,000 and US\$ 10,000 yearly with a slight upward trend. After deduction of salary cost, remaining net margins are nil or even negative, but seem to slightly improve over time.

The loan in 2002 actually had a slightly disturbing effect on the operations of USISS as it mainly made available working capital (e.g. it permitted to buy a higher stock of plastic bags). Just before the loan was acquired, much attention went to obtaining the loan. Afterwards, according to the present USISS director, acquiring and installing the equipment required some special attention. Also it is not clear if the relatively high amount of working capital made available through the loan stimulated production activities or slowed them down by enabling more profitable non-drying activities.

In table 1, average and total values for revenues, costs and benefits are presented for the whole analyzed period. The net margin of solar drying over the period has been slightly negative, even without taking into account the investment made. Including the commercial activities with dried shallot, the picture is more positive. However, due to the risky character of such activities and special competences required, USISS could not compete with the other traders in this market and abandoned the activity.

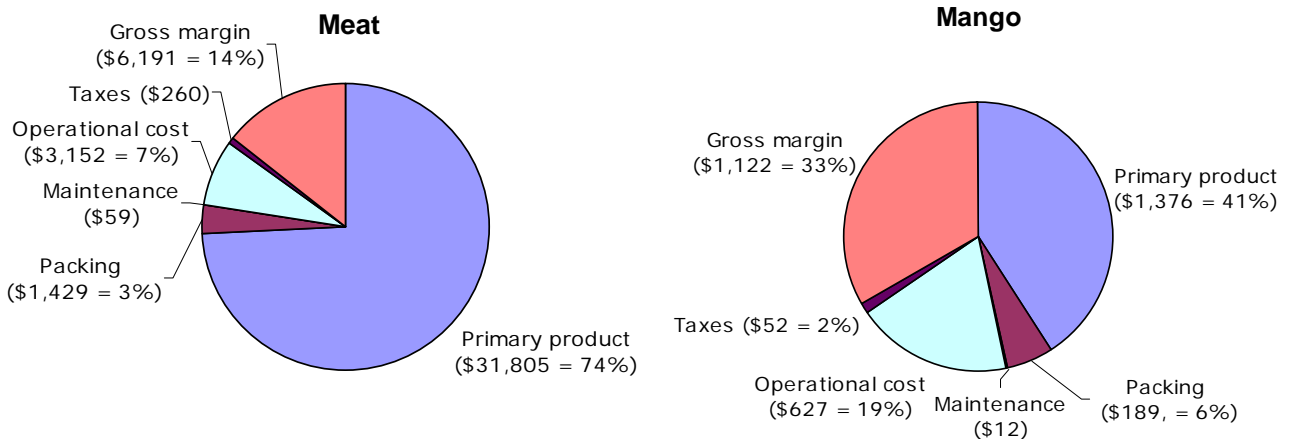
Table 1. Costs and benefits of the USISS enterprise over the period 2000-2007

	Total over period US\$	Yearly average US\$
Revenues		
Sales of dried meat	327,217	40,902
Sales of rest meat	15,957	1,995
Sales of dried mango	27,021	3,378
Total revenues	370,195	46,274
Costs		
Primary product for meat	254,439	31,805
Primary product for mango	11,010	1,376
Packing material	12,948	1,619
Total costs	278,397	34,800
Value added on drying	91,798	11,475
Small maintenance	565	71
Operational cost	30,229	3,779
Taxes	2,492	311
Total costs for drying	311,682	38,960
Gross margin of solar drying	58,512	7,314
Salaries and other remunerations	74,003	9,250
Net margin of solar drying	-15,490	-1,936
Investment made	5,634	
AREED loan (present US\$)	29,646	
Repayment of AREED loan (including interest)	43,927	5,491
Net margin with investment and loan	-35,406	-4,426
Commercial activities		
Sales of dried shallot chips	72,689	9,086
Estimated income	20,768	2,596

Including the effects of the AREED loan in the analysis, the net margin would further deteriorate, but it would not be realistic to charge the total costs of the loan to the drying activities. Part could have been used to finance the shallot trade, part for other purposes. An estimation of the amount of the loan used for drying would probably be between 10 and 30%.

Costs and benefits for meat and mango drying are different (see graph 3). In fact the drying of meat constitutes, by its volume, the stable basis of the USISS enterprise, but the value added of the dried product with respect to the fresh product is quite low. This means

that the product is sensitive to price increases of meat, as is presently the case. USISS responded to the price increase over the past years by gradually decreasing the weight of the packages from 50 to 40 grams, a practice that cannot be continued forever. Gross margins for meat and mango, when expressed per day of labour, are similar. But because of the relatively high price of raw meat, mango drying is much more profitable with respect to the needed working capital. Increasing this market probably helps the enterprise most (see chapter 3). Operational costs, partly caused by the rent of the site, are relatively high.



Graph 3. Average yearly margins for meat and mango solar drying.

### 2.2.2 Upstream and downstream costs and benefits

Along the value chain, price increases enable other people to make a living out of the production activity of USISS. For both products, meat and mango, downstream data have been collected through the interviews with USISS clients. Upstream data have been gathered through interviews with traders, producers and specialists at the ministry of animal husbandry.

Figures 6a and 6b represent the value chains of meat and mango, with associated value increase of the product. With the mentioned data, values added along the value chain have been calculated (table 2).

Table 2. Value added (US\$) along the value chains with USISS involvement (2007/2008 price levels)

	Producers	Traders	Slaughterers	USISS Drying	Retailers	Total
Meat, per kg dry meat	12.16	2.85	1.70	5.88	6.62	29.21
Meat, per year (2132 kg sold)	25,912	6,075	3,625	12,530	14,114	62,256
Mango, per kg dry mango	4.17	0.57		6.89	7.95	19.58
Mango, per year (290 kg sold)	1,211	165		2,001	2,310	5,688
USISS per year	27,123	6,240	3,625	14,531	16,425	67,944
% of total value added	40%	9%	5%	21%	24%	100%

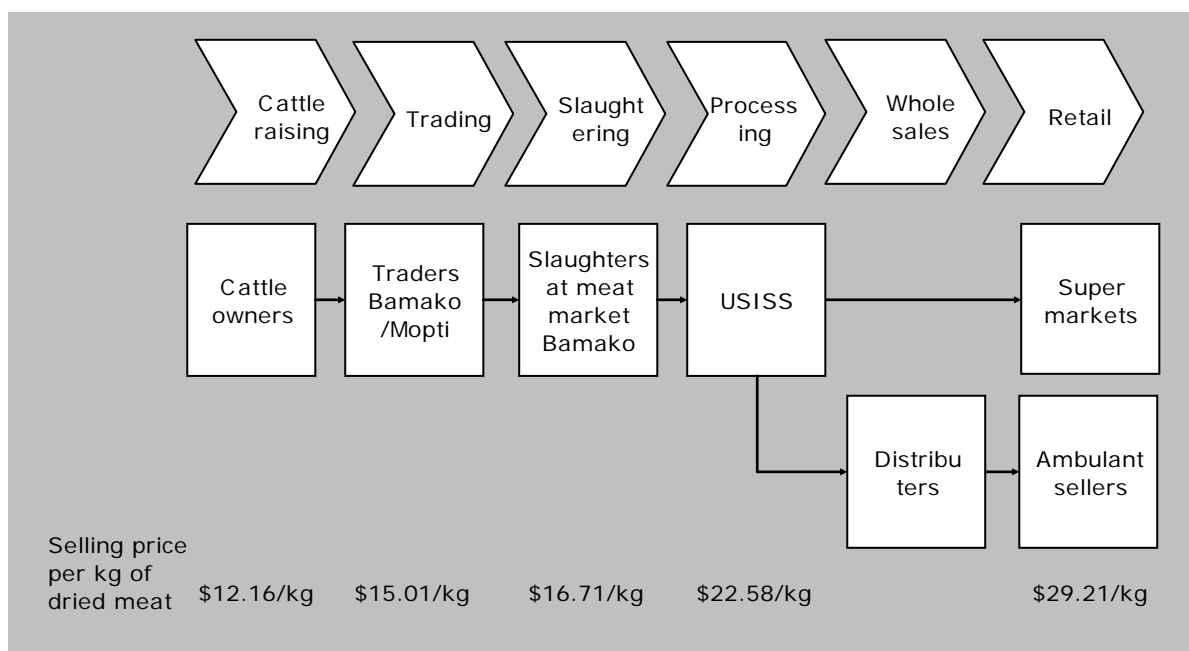


Figure 6a. Value chain for USISS dried meat and value added (2007 values).

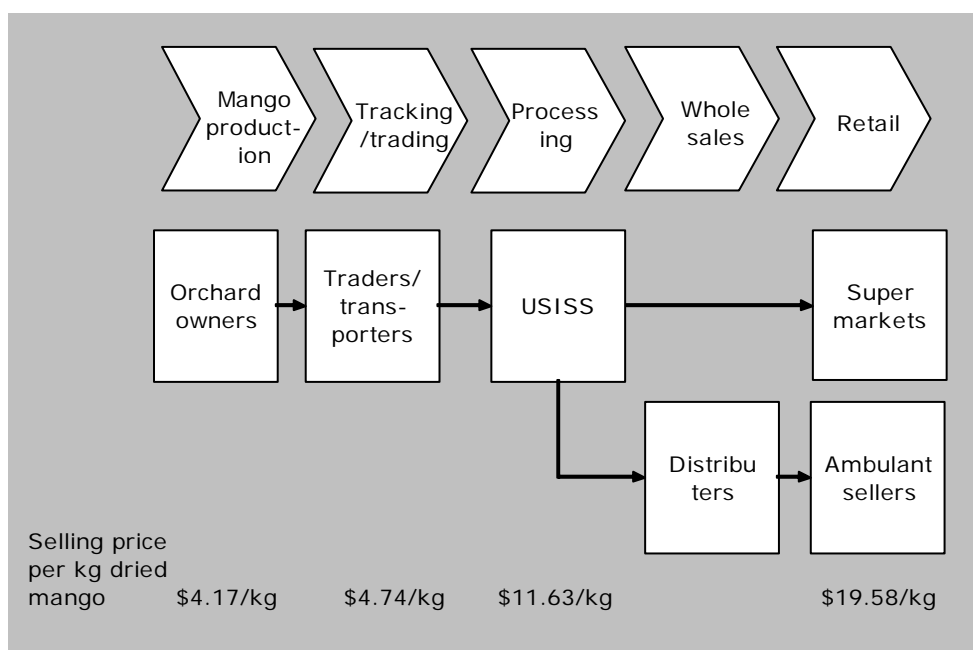


Figure 6b. Value chain for USISS dried mango and value added (2007 values).

From the calculated data (table 2) it appears that value added along the complete value chain is nearly four times higher than that of USISS itself.

The value added through waste removal should be added to this. Yearly USISS sells around 50,000 plastic bags (240 kg, around 1-2 m<sup>3</sup>) that should be removed, mainly from the city of Bamako. Total costs for removal of city waste is estimated between 4-8 US\$ per m<sup>3</sup>, thus the value added for removal of the plastic bags from the city is estimated between 4 and 16 US\$ per year. In any case this is less than 1% of USISS value added and thus negligible in the total costs and benefits generated during the life cycle of USISS products.

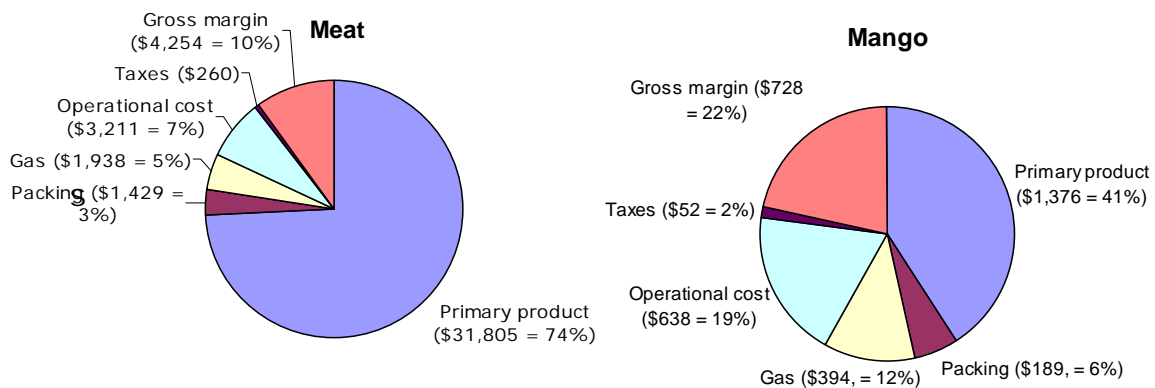
### 2.2.3 Marginal analysis

Through marginal analysis costs and benefits of solar drying can be compared with those of a reference technology, in this case fuel based drying.

Mangoes are most frequently dried with gas, a technology introduced in Southern Mali by Helvetas, a private organisation for development co-operation in Switzerland ([www.helvetas.ch](http://www.helvetas.ch)) in order to support women groups in processing surplus mangos (see also chapter 3). Normally about 1 kg of gas is used for each kg of dried mango.

Meat is sometimes dried in the open air in the sun, without further treatment. In some areas meat is smoked with wood. However, in both cases the product is not comparable to that of USISS (capital cost of the solar dryer make the USISS product more expensive, but its hygienic quality and shelf life is better). The only comparable product could be obtained by gas drying. Meat dries quicker than mango, taking only two instead of three days and therefore it is estimated that 1 kg dried meat would require 0.67 kg of gas.

With a price of 7000 FCFA per 12 kg bottle (1.36 US\$/kg) the total average costs for gas would be around US\$ 2332 per year (using 1719 kg of gas). This would increase the costs for inputs with around 7% and reduce gross margins with 32%. Investment costs for equipment for gas and solar drying are not very different, thus in principle solar drying would be more profitable. However solar drying as a technology is more difficult to master as it requires knowledge to adapt the drying process to the specific weather conditions in each season and at each location. With gas drying, the margins for meat and mango as presented in graph 3 would read as in graph 4.



Graph 4. Average yearly margins for meat and mango with gas drying.

Marginal costs and benefits of solar drying are mainly confined to the drying process itself. No major consequences are identified for other processes in the value chain. For gas the import price constitutes the main costs while local handling costs present only a minor fraction. Thus the contribution of the use of gas to the economy of Mali is limited.

## 2.3 Social costs and benefits

In Mali, based on the earlier developed poverty reduction strategy (Cadre Stratégique de Lutte contre la Pauvreté), a more recent policy has been formulated orienting agricultural development. This policy (Loi d’Orientation Agricole) stresses modernisation of agricultural production while promoting sustainable use of natural resources. It puts a value chain approach at the front place, stimulating a better organisation of production, storage, processing, marketing and trading. Increasing income through development of the agricultural sector is considered key to poverty reduction. Thus for this case study, social costs and benefits are directly linked to revenues generated for low-income groups.

### *2.3.1 Direct social costs and benefits by USISS*

Direct social benefits for the USISS employees are threefold:

- They have an income through the drying activities. Over the period 2000-2007, the income from drying is estimated between 5000 and 7000 US\$ yearly (table 1) which for the five employees makes an income of around 4-5 US\$ per day, keeping them and at least part of their families well above the poverty line.
- Furthermore they have specific knowledge on drying meat and mango. During the analysed period they have been asked twice to give formal courses on the subject (getting a fee of around 60 US\$). On average once a month people come consulting them on drying practices. In case of scaling up of solar drying in Mali there would be a possibility of using their knowledge more systematically. But by doing so they also would contribute in helping their own competitors unless they would be co-owner of the developed businesses.
- Thirdly they have cheap access to meat and mango, and thus to healthy food, although the exposure to raw meat might entail some health risks.

Outside the scope of the analysis fall the benefits from activities other than drying such as the joint buying and selling of shallot and cereals.

As indicated in chapter 2.1.3 on the used methodology, no social costs have been identified for the USISS enterprise, as it is well integrated in the Malian cultural system. Through the employees salary the total social benefit for USISS personnel in 2007/2008 is evaluated at around 9000 US\$ yearly.

### *2.3.2 Social costs and benefits along the value chain during the life cycle*

The fraction of product processed through USISS (or in case of up-scaling through other enterprises) represents only a minor part of the total production. Thus it is not expected that the processing will generate changes for the producers in access to education and health. Therefore at the upstream side, the analysis pertains to increased income of vulnerable groups.

For meat and mango the situation is very different. Hardly any herdsmen own the cattle they herd. So the value added flows first to cattle owners who are better-off than herdsmen. In general herdsmen have flocks of around 60-70 heads with a yearly meat production of 340 kg (3% exploitation rate, 175 kg/animal). Their income is at or slightly below the minimum level of 1 US\$ per day, around 340 US\$ per year. This leads to an income of around 1 US\$ per kg meat (on the hoof) which still represents around 70% of the meat value. For mango the total revenues go to the producer. Most are small producers, but about 10% own orchards over 10 ha, producing around 30% of the total production. Hence small farmers produce around 70% of the mango production. These data are used in table 3 to present the low income wages generated at producer level.

Upstream, value added by traders and slaughterers leads to more employment. From interviews with mango traders it is estimated that in the traditional system with trackers and traders, about 24% of the added value is for low income wages. USISS tries to diminish those costs through buying from a few preferred clients. The slightly reduced figure for mango trading and tracking (20% of added value for low income wages) was also used for meat trading and slaughtering (see table 3).

For the drying by USISS, we consider all gross margins as low income wages. About two third of the added values consists of gross margins (for meat with 64% somewhat lower than for mango 72%).

Downstream at retailer level, part of the value generated by sales of dried meat and mango will be used for capital costs and imported material (functioning of the



supermarkets). For Mali in general this percentage is around 35%). Thus the generated low income wages (labourers in supermarkets, street vendors) are estimated at around 2/3rd of the total value added.

With these data the social benefits of USISS along the value chain are assessed through the employment generated for vulnerable groups (table 3).

Table 3. Low income wages generated through USISS along the value chain (2007/2008 price levels)

Social benefits (US\$/year)	Producers	Trading/ slaughtering	Drying	Retailing	Total
Meat value added	25,912	9,700	12,530	14,114	
Low income wages (%)	70%	20%	64%	65%	
<b>Social benefits meat</b>	<b>18,138</b>	<b>1,940</b>	<b>8,052</b>	<b>9,174</b>	<b>37,304</b>
Mango value added	1,211	165	2,001	2,310	
Low income wages (%)	70%	20%	72%	65%	
<b>Social benefits mango</b>	<b>848</b>	<b>33</b>	<b>1,448</b>	<b>1,502</b>	<b>3,831</b>
<b>Social benefits USISS</b>	<b>18,986</b>	<b>1,973</b>	<b>9,500</b>	<b>10,676</b>	<b>41,135</b>
%	47%	5%	23%	26%	100%
Persons earning a living	52	5	5	29	92

Total generation of income for vulnerable groups is evaluated at around 40,000 US\$ yearly, half of which is at the upstream side.

Consumers of the USISS products are part of the well-off class in Mali. As such, the consumption of the products hardly improves the health of the poor and is not considered as social benefit<sup>3</sup>. As for the economic analysis, social benefits through waste collection are relatively low, at maximum 10 US\$ per year.

### 2.3.3 Marginal analysis of social costs and benefits

Comparison of solar drying and gas drying reveals no specific difference in social costs and benefits.

## 2.4 Environmental costs and benefits

Environmental policy in Mali is formulated in the National Policy for Protection of the Environment (PNPE) concerning both rural and urban environment the related institutions (see e.g. Profil Environnemental du Mali, European Commission, 2006). The policy is mainly confined to public sector activities.

For new enterprises environmental impact studies are required since 2003, but no financial incentives are connected with the results of such studies. Thus, environmental costs and benefits presented here for the life cycles of USISS' products are not entering USISS own accounts nor those of other actors involved.

### 2.4.1 Direct environmental costs and benefits by USISS

Direct environmental costs pertain to use of water, electricity, and to the plastic bags used for packing dried meat and mango.

Water use of USISS is quite low. Although in Mali there is a water shortage for agriculture and cattle, the quantities used by USISS are too low to modify the general environmental

<sup>3</sup> Woman groups supported by Helvetas in gas drying of mango sell their surplus dried mango to schools, where it enters in the diet of school children. This will help them getting some healthy snack. With a scolarity of only 50% in Mali and only about 20% of 15- to 29-year-olds have completed primary school (World Bank 2007), it is not expected that this helps in improving the diet of the very poor that do not attend school.

impacts of water use. Even if environmental costs are valued at the highest price levels for industrial users (from US\$ 0.26 up to US\$ 1.20/m<sup>3</sup>, higher if consumption is high), the environmental costs of USISS water consumption would remain low (0.01% of the yearly USISS cost).

The average electricity consumption is around 2000 kWh per year. A conventional electricity plant as in Bamako, produces around 0.88 kg CO<sub>2</sub> per kWh. Thus for the electricity USISS consumes annually, there is 1790 kg of CO<sub>2</sub> produced. With a CO<sub>2</sub> environmental costs of US\$ 8/ton (which is the carbon sequestration value) the environmental costs are valued at US\$ 14 yearly.

Selling of around 48,000 plastic bags yearly (à 5 grams) burdens the city of Bamako with 240 kg of poly ethylene bags. This is partly collected and thus accounted for in chapter 2.2.2. The plastic is slowly degrading or burned. It then produces around 648 kg of CO<sub>2</sub> with an environmental costs of US\$ 5 (again valued at US\$ 8 per ton CO<sub>2</sub>).

Thus the enterprises' general environmental costs, which are not accounted for in the current price levels for resource use, are low, absolute and with respect to the total costs of the enterprise (see table 4). Even when these environmental costs would have been charged to the enterprise, this would not affect its profitability.

#### *2.4.2 Environmental costs and benefits during the life cycle of the two products*

##### *Meat*

Environmentally, consumption of meat proteins requires more resources than consumption of cereal proteins. In the case of Mali however meat is mainly produced through a transhumance system where herds exploit areas where rainfall is too erratic to produce cereals. Therefore environmental costs of meat production and consumption along the value chain are mainly associated with meat production itself: with possible overgrazing of the pastures in middle and Northern Mali.

The question is then whether overgrazing takes place or not. Recent policy papers of the ministry of animal husbandry (Ministère de l'Élevage et de la Pêche, 2004) indicate that the total biomass available in the meat producing areas in Mali is around 60 million tons per year for a requirement estimated at 20 million tons. In 2003, 43% of the carrying capacity of the pastures in Mali was used, so generally overgrazing is not expected. Locally, degradation as a result of overgrazing could occur. However, since the USISS enterprise uses only an estimated 0.01 % of the national meat production, contribution to local overgrazing is not expected.

A small environmental benefit is generated through slaughtering, as blood and bones are sold as fertilizer thus providing nutrients for agricultural production and preventing soil nutrient depletion in the fields it is applied. These nutrients have however been ingested on the pastures and thus the process concerns a displacement of nutrients. The net environmental benefit is assumed zero in this case.

Transport of meat can be over long distances, but USISS meat comes from nearby and is mainly transported on the hoof.

##### *Mango*

The environmental costs associated with mango production are mainly those connected with the use of pesticides and with transport of the mango.

At present most traders discourage use of pesticides as it could cause problems with export. As a consequence use of pesticides in mango production is limited and more exception than rule. Environmental consequences are still limited.

Transport of mango for USISS is limited. Over the analysed period most mango is bought around Bamako, 70% at Siby, which is at four km from Bamako, 25% from Baguineda (at 38 km) and 5% from Bamako. Average transportation distance is then 12.5 km. From the orchards to the market places distances are limited as well (generally less than 10km, average estimated at 7.5 km). Thus it is estimated that transport by middleman/trackers (plus return) is on average 40 km in small lorries of around 2-4 tonnes consuming about 10 litres of gasoline per journey. This would mean that for the five tons yearly dried by USISS at maximum 20 litre of fuel would be used for transport, emitting 60 kg of CO<sub>2</sub> with a value of 0.5 US\$.

Table 4 Average yearly environmental costs and benefits for the complete lifecycle of USISS products.

	Environmental effect	Quantity	kg CO <sub>2</sub> emission (equivalent)	Value US\$/year	% on total cost
<b>Production</b>					
meat	Overgrazing	no evidence		-	-
mango	Use of pesticides	low		-	-
<b>Transport/trading</b>					
meat	transport on the hoof			-	-
mango	Fuel (L)	20	60	0.5	0.001%
<b>Slaughtering</b>					
	fertilizer production			-	-
<b>Processing by USISS</b>					
	Water (m3)	5		6	0.015%
	Electricity (KWh)	2034	1790	14	0.036%
<b>Consumption</b>					
	Methane offset (kg)	-400	-8400	-67	-0.172%
<b>Waste</b>					
	Plastic bags (kg)	240	648	5	0.013%
Total costs			2498	25	0.065%
Total benefits			8400	67	0.172%
<b>Total net benefits</b>			<b>5902</b>	<b>42</b>	<b>0.107%</b>

Assuming that the five tons of mangos used each year by USISS would otherwise rot, the enterprise also offsets GHG emissions in the form of methane from waste decomposition. With 15% of carbohydrates in mango (producing at maximum 533 kg of methane per ton carbohydrate), maximum methane emission of 5 tons could be around 0.4 ton/year. Contribution to global warming of methane is about 21 times higher than that for CO<sub>2</sub> thus its environmental costs is set at 168 US\$/ton of methane. Yearly environmental benefits by offsetting 0.4 ton methane production are evaluated at 67 US\$.

An overview of all environmental costs and benefits is given in table 4. Values appear to be very low in comparison to the conventional costs of solar drying.

#### 2.4.3 Marginal environmental costs and benefits

Marginal economic costs and benefits of solar drying with respect to drying with wood, charcoal or gas have been treated in paragraph 2.2.3. They are purely confined to the drying process itself. No major consequences are identified for other processes in the value chain. The associated environmental costs that would have been made if USISS

would have applied gas drying for its production are included in table 5. In that case the slight environmental benefit of the USISS enterprise of 42 US\$/year (table 4) would be completely annulled.

Table 5 Average yearly environmental costs savings from 2000 – 2007

	Quantity (kg gas)	kg CO2 emission	Value US\$	% on costs primary product
Gas dried meat	1428	4285	34.28	0.11%
Gas dried mango	290	871	6.97	0.51%
Total	1719	5156	41.25	0.12%

As for the enterprises general environmental costs, also the marginal environmental costs and benefits are low, absolute and with respect to the other costs of primary material. Even if USISS would have been compensated for avoiding the environmental costs of gas drying, this would not affect its profitability.

## 2.5 Summary of findings

### *The enterprise*

USISS appears a local enterprise well adapted to the entrepreneurial context in Mali. It is small and margins are low. Yet, the enterprise is stable and its margins are slowly increasing. Continuing such an enterprise in the prevailing context can be considered already as a success.

The expectations of the AREED loan were not met. A summary of conclusions and recommendations with respect to the use of this type of loans is included in annex 3.

USISS' production costs are relatively high, due to the costs of the solar drying equipment<sup>4</sup>, the high rent for the production site in the centre of Bamako and the relatively high salary costs in that capital.

The enterprise generates considerable social benefits along the value chain. Valuing these benefits through the generated income for low-income groups, the USISS gross margins are multiplied with more than 4 over the entire value chain, producing a yearly income of US\$ 40,000 for vulnerable groups. In this respect the AREED loan of US\$ 20,000 is fully justified.

Environmental costs and benefits costs and benefits not accounted for in conventional cost-benefit analysis relate to natural resources depleted, CO<sub>2</sub> production or sequestration and waste produced. They appeared however to be of minor importance when valued against current rates. Benefits were evaluated at around US\$ 67 per year (representing less than 0.2% of the total costs of solar drying and less than 1% of the enterprises gross margin). Environmental costs were evaluated at 25 US\$ per year.

### *Policy context*

The conventional analysis shows clear benefits of solar drying with respect to gas drying. The difference in resource use - free solar energy or gas -, is directly translated in the costs for inputs and thus in the conventional analysis (7% difference in the costs for drying, 32% in gross margins). Environmental costs and benefits non-accounted for in conventional analysis appear to be low (<0.2% of the costs for drying). Subsidies that would transfer net environmental benefits from solar drying to an enterprise like USISS would therefore hardly influence the margins of the enterprise.

<sup>4</sup> In fact, the solar drying technology is not yet mature in its development.

While solar drying would be a cost-effective way of drying, certainly in the hot and dry climate in Mali, the technology is not yet well developed for the local conditions. Knowledge on adaptation of drying procedures to specific weather conditions is lacking and equipment, based on imported material, is more expensive than needed if local material would have been used. The Mali centre for solar energy focuses mainly on solar panels for generation of electricity and not much on solar drying. Solar drying enterprises like USISS are hardly assisted with knowledge on drying techniques and on equipment and its costs.

#### *Methodology*

One of the advantages of the method used for the present study is that it describes a real enterprise with all its specific properties and problems. A drawback is that conclusions on the costs and benefits of solar drying in general are more difficult to draw, especially if it concerns the analysis of scaling-up programs. Two effects are expected when scaling-up would occur: the margins could improve as a result of cheaper equipment, better drying practices, location of businesses in places with lower costs for building and with lower wages; on the other hand margins could reduce as a result of increasing competition. The result of these effects will be largely influenced by the evolution of the market demand for dried products.

Furthermore, identification in an early stage of main non- conventional environmental and social costs and benefit factors is important. Then they can be roughly assessed in order to decide if further investigations are necessary.

### 3 Market assessment

An assessment of the markets for dried meat and dried mango has been carried out in order to explore to which extent a solar drying activity such as the USISS enterprise undertakes could be multiplied and to identify the most important constraints and opportunities.

The study combined data from various reports, interviews with resource persons<sup>5</sup> and a survey among 31 retailers out of which 28 were clients from the USISS. The survey was carried out to assess the volume of dried meat and mango sold in Mali and to investigate the retailer's ideas on potential market possibilities for dried mango, meat and other dried products. They were exposed to a structured questionnaire. Two out of 28 of the USISS clients are selling outside Bamako, one of them in Niono and another one in Sikasso.

#### 3.1 Meat market

Meat production in Mali is increasing (see table 6). Export of meat is outweighing national consumption. In 2003 eg the number of cattle exported was estimated at 491,321. Virtually all exports are living cattle.

Table 6 Estimated beef production in Mali

Year	Total nr of cattle	Production (10.3%)	Export (nr of cattle)	Slaughtered in Mali (nr of cattle)	Beef produced in Mali (tons)
1995	5,700,000	587,100	457,539	129,561	16,843
2000	6,500,000	669,500	458,177	211,323	27,472
2003/4	7,398,058	762,000	491,000	271,000	35,198

Source: Ministry of Animal Production, 2004, 2005

With respect to these quantities the yearly use for meat drying by USISS is low (10 t, or about 0.03% of national meat consumption and about 0.01% of national meat production).

##### 3.1.1 National market for dried meat

The local market for dried meat seems limited. In Mali five groups have been identified drying meat on an artisanal scale, one in Kati (town near Bamako), two in the region of Koutiala and two in the region of Koulikoro, including Bamako (Ministry of Animal Production, 2005). USISS is the only unit that dries meat on a semi-industrial scale. In view of the limited capacity of the other groups and USISS' good network of retailers, the enterprise is estimated to cover presently about 80% of the present dried meat market in Mali.

In some areas in Mali (Kayes region), meat is dried in the sun without cover. The product is less hygienic and not used in Bamako.

The 28 interviewed USISS retailers sell together around 1,369 sacks of dried meat per week which is around 45% more than the total USISS sales (if extrapolated to a 52 week year). Probably the indicated weekly sales are aspired sales, higher than the yearly average. Furthermore, some dried meat from other providers might have been sold as

<sup>5</sup>) For assessing the international market for meat and mango, the following enterprises have been interviewed: Mavideniz; production and marketing of organic sun dried mango in German health stores (Morgenland); Zonnig fruit; production and marketing of sun dried mango in health stores in the Netherlands, Catz International; Rhumveld Winter&co; Tradin Amsterdam; Imko BV; packing of nuts and dried fruits in Europe; Doens food. Local information has been obtained through contacts with Jean-françois Cruz, CIRAD, Montpellier, France; IB Negoce, Bamako; Ministry of Animal Husbandry Mali.

well, although during the interviews this was not mentioned by the retailers. The average selling price of 29.21 US\$/kg has been used in the value chain analysis (figure 6a).

Around the end of 2007 price changes occurred. About 70% of the clients confirmed that the price of meat had changed mainly because of butchers being (temporarily) on strike. Further, around half of the clients responded that they sometimes change the selling price during the year. The demand for dried meat increases during the tourist months (December – February), the school holidays, and the hot season. Also, the demand significantly decreases during short periods following the main Muslim holidays like Tabaski. Yet, in general, beef production is stable throughout the year, so besides the effects mentioned above, large price fluctuations during the year, as for agricultural products, do not occur. Presently (August 2008), as a result of increasing prices of fodder, the beef price is still high with respect to the prices during the study (16% higher).

The retailers responded to the main advantages of USISS dried meat as follows: 1) very good quality product (67% of the clients), 2) easy to conserve (25% of the clients), 3) easy to consume (12%). USISS delivers its product in 50 gram sacks by motorbike and the clients mentioned that they are not selling products of other producers, because USISS has the best quality. Further, the results show that dried meat is consumed by Malians and foreigners and sells well with beer.

Only a small number of clients (7%) mentioned that they did not get the required quantity of USISS, which was partly related to the strike of the butchers when less meat was available. Some major clients, however, indicate that the product is not always timely delivered and that sometimes their shelves are empty. The USISS manager noted to this phenomenon that these clients have spontaneous orders to export dried meat to Europe and that he could not base his production on these incidental demands.

Asked for possibilities to improve the sales of USISS products, the interviewed retailers gave a number of suggestions. The three main suggestions given pertained to temporal price offers, which in principal the retail sector could organize itself. These suggestions were:

- Stimulate sales by sometimes reducing the prices ;
- Sometimes provide an extra sack for free ;
- Distribute the products freely so that new consumers get to know the product;

During planned meetings between USISS and retailers this type of campaigns could be discussed and organized.

A second group of suggestions concerned the use of radio and television to better market the product. In the past USISS tried to organize some publicity. Around 2000, radio messages had been prepared but have been broadcasted only a few times. Even some publicity sketches have been made for TV, but no budget for broadcasting had been found. No information is available on costs benefits of this type of advertisement for USISS products.

Thirdly it was suggested to technically improve the packaging of the product and make it more attractive. Presently dried meat and mango is packed in poly-ethylene bags which has no moisture barrier and does not show well the product because of its opacity.

### 3.1.2 Regional market for dried meat

Data on the regional market for dried meat are scarce. Presently hardly any dried meat is exported from Mali to the West African region. Meat export is mainly in the form of living cattle (see table 4) transported on the hoof by herdsmen to the coastal region, as this involves hardly any barriers.



Figure 7. Dried meat at the market in Kumasi

Market potential for dried meat from Mali seems to exist, especially in West African coastal region, where conditions for solar drying are less favourable than in Mali. In Kumasi, Ghana, there is an important market for dried meat (figure 7<sup>6</sup>). In the other coastal regions the potential would probably much smaller, as data on imports of meat products suggest (table 7).

Table 7. Import data (2003, US\$ x 1000) for meat and edible meat residues (offal), salted, in brine, *dried or smoked*; flours and meals of meat.

Ghana	Ivory coast	Nigeria	Benin	Togo	Guinea	Gambia
1,783	170	60	43	40	32	9

Source International Trade Centre UNCTAD/WTO (<http://www.intracen.org/tradstat/sitc3-3d/ir288.htm>)

A company (African Trading Company in Niamey, Niger) producing a similar product *killishi* (or *killichi*, dried meat soaked in a spicy extract) was reported in 1998 to annually sell around 4800 kg of the product (2.4 x the USISS production on the regional West-African markets (Niamey, Benin, Togo, Burkina Faso, Ivory Coast and Senegal, UNIDO, 2002).

### 3.1.3 International market for dried meat

The marketing in Europe for dried meats is limited as dried meat is not a standard part of the diet of most European cultures. However, several European countries have groups of South African immigrants who have a strong culture of eating dried meats as a snack, called biltong. The largest population can be found in the United Kingdom, where according to the last UK Census (2001) 140,236 people from South African origin live. The actual number of South Africans in the UK could perhaps be three times as high, as many hold a British passport. Smaller populations of South Africans can be found in other European countries, most notably the Netherlands.

The UK has a large network of South African shops where dried meat (biltong) is likely to be the biggest selling product. However, the UK government (HR Revenue and Customs) has forbidden the import of all meat products from outside the EU, including meat for personal use. As a result biltong sold in the UK is locally made from locally purchased meat.

With about eight big sellers (estimated to sell around 400 kg of dried meat/week), 50 small (estimated to sell around 20 kg of dried meat/week) and 200 South African shops

<sup>6</sup> [http://www.virtualtourist.com/travel/Africa/Ghana/Ashanti\\_Region/Kumasi-2033887/Shopping-Kumasi-BR-1.html](http://www.virtualtourist.com/travel/Africa/Ghana/Ashanti_Region/Kumasi-2033887/Shopping-Kumasi-BR-1.html)



and bars (also estimated to sell around 20 kg of dried meat/week), the total yearly sales in the UK are estimated at 200-300 tons of dried meat.

The Netherlands also has (online) South African stores which sell biltong, although these generally have an informal character. Once again the biltong sold is produced in Europe from European meat. The explanation given by these stores is that the current laws make it too complicated to import from outside the EU. One store claimed it had been approached multiple times by South African producers, and agreed to buy if permits could be acquired. However, none of these suppliers have acquired the necessary permits.

#### *3.1.4 Constraints and options*

Mali exports more living cattle than meat from cattle slaughtered in the country (table 6). This could indicate that the local meat market is satisfied at the current price levels and will only increase if the income of the consumers grows further. Indeed, a richer urban class is rapidly growing indicating that there is local market potential for dried meat if the product enters in the consumption habits of this urban group. On the other hand, in the past seven years, the rather stable USISS production and the stable price level indicate that no strong growth can be expected. Effects of marketing campaigns as suggested in paragraph 3.1.1 are still unknown. For the moment, it is estimated that with one or two other drying units the national demand would be more than satisfied at the current price level.

Reducing prices has been proposed by the majority of the surveyed sellers. Some price reduction could be realized through improved production efficiency, but not much, as the raw material makes out already 75% of the total product costs (chapter 2). Temporally price reductions and other marketing campaigns could be options to test.

Theoretically, the regional market would offer possibilities. Demand exists in particular in Ghana and solar drying in (Northern) Mali would certainly be an option to consider as the climatic conditions for solar drying are better. For the moment however, barriers for transport and regional export (check points along the roads) continue to exist, even though the formal policy of the Economic Community of West African States (ECOWAS) aims to create a free trade area through the elimination of tariff and non-tariff barriers among member states. As long as these barriers exist, it is cheaper and less risky to track with living cattle to the West African coastal region in stead of transporting the final product and competition with dried meat products made locally from imported cattle seems rather strong, even though the local drying conditions are worse.

In Europe there is demand for dried meat, but although the EU does not forbid the import of meat from outside the EU, it is subject to stringent laws and regulations, most notably law 97/78 of the European Commission of 18 December 1997. This law states that any shipment of meat products from outside the EU need to be checked by a veterinarian on micro biological content which includes laboratory tests. Furthermore all products need to come with detailed documentation. Unless the exporting country can prove that there is sufficient quality control a check of every shipment is mandatory. It is not likely that the current producers in Mali will be able to set up a process of producing dried meats that satisfies all European regulations and standards. Thus, export of dried meat from Mali to Europe is not a viable option. Furthermore, even if import restrictions would be less stringent, South African producers would have a decisive advantage due to their relationships with South Africans in the UK.

#### *3.1.5 Estimated market review*

On the basis of the above mentioned data, an estimation of actual and potential markets for dried meat is resumed in table 8.

Table 8. Estimated market data for dried meat (1000 US\$/year).

	Local market	Regional Market	International market
USISS sales	53	-	-
Mali sales	65	-	-
Actual market	75	1,000	10,000
Potential market	150	2,500	10,000
Main barriers (see also next chapter)	- low purchasing power - expensive technology		low production scale
		regional trade barriers promote 'informal' transport fresh meat on the hoof (cattle)	severe international trade requirements

### 3.2 Mango market

The total production of mango in Mali is estimated around 200,000 tons per year. International export of fresh mango is rapidly increasing, but with an estimated 4,500 tons per year in 2007 (GRAT, 2008), it still constitutes a minor fraction of the total production. There is also regional export to Senegal and Mauritania. Between April and July, when most mangoes are harvested, the production is higher than the national consumption plus export and less appreciated varieties and low quality mangos are left rotting. During that time prices are low and there is a real need for conservation and processing of the fruit. Hence drying of mango offers a good opportunity to profit from the price fluctuations. Besides drying there is some artisan production of mango juice and jam, and some first tentative production of mango pulp for export.

#### 3.2.1 National market for dried mango

In many households mangos are dried occasionally in the open air for snacks, but these are only by exception sold to others as the product deteriorates quickly. USISS is the only firm in the city of Bamako producing dried mango in a semi-industrial way. The total sales of around 400 kg per year are estimated to be not far from real demand at the actual price level, since only a small number of USISS clients (7%) mentioned that they did not always get the required quantity. With a growing urban middle class, there is some potential for market increase, but the dried mango market is far from perfect and it is still a question how USISS could profit (see at the end of this paragraph).

Presently the local market for dried mango is still small. Only 7 of the 28 interviewed clients of USISS sell dried mango, a total of 284 sacks of dried mangos per week, mostly when fresh mango is not available (2/3 of the year). Even then the indicated sales are 20% higher than the USISS sales. Like with meat the indicated weekly sales may be aspired sales and some dried mango from other providers might have been sold as well. The average price of 19.58 US\$/kg has been used in the value chain analysis (figure 6b).

The interviewed retailers responded to the main advantages of USISS dried mangos as follows: 1) good quality product, 2) easy to conserve, 3) easy to consume, 4) USISS has a good reputation and finally the dried mango does not have a bad smell. USISS delivers its product in 50 gram sacks by motorbike and like for dried meat, the clients mentioned that they are not selling products of other producers, because USISS has the best quality. Similar suggestions were provided as for dried meat to improve marketing of dried mangos. Here especially the packaging was mentioned. The dried mango, after 6 months or so, tends to lose its bright yellow colour.

In the southern part of the country, HELVETAS and GRAT (Groupe de Recherches et d'Applications Techniques) assist producers in producing certified organic mango, which is exported to Switzerland through Burkina Faso, where mango processing and trade are more developed than in Mali. As a part of this program presently 27 gas dryers are used by various groups to produce dried mangos for the European (Swiss) market. Although the contract for 2007 was 6 tons, they produced only 1.7 tons exportable quality and 1.6 tons that was sold at the local market (GRAT 2008). It should be noted that the price levels these producers sell are lower than the USISS prices (see table 9) and also that they sell a 1<sup>st</sup> quality product at a lower price to the exporter than on the local market. Apparently the national market for dried mango is far from efficient, making it uncertain whether the good USISS margin (chapter 2) can be maintained after scaling up (e.g. if HELVETAS would expand their support to mango processors to the Bamako region).

Table 9. Quantities of dried mango produced in Mali in 2007 and selling prices.

Product	kg produced	Price (FCFA/kg)	Price (US\$/kg)
USISS product selling price	410	5000	12
USISS product retail price	„	8420	20
Helvetas 1 <sup>st</sup> quality export	1279	3000	7
Helvetas 2 <sup>nd</sup> quality export	405	1500	3.5
Helvetas 1 <sup>st</sup> quality local		4500	10.5
Helvetas 2 <sup>st</sup> quality local		500	1.2
Helvetas local market all	1604	±3500	±8

Data kindly provided by Helvetas Mali

It can be questioned whether with the high costs of salaries and the high rent for a building in the heart of Bamako, an enterprise like USISS can compete with women groups and entrepreneurs in the rural areas when the market becomes more efficient. Yet, while for the USISS enterprise some price corrections could become inevitable in the long run thus reducing the margins on their mango drying activity, in general prospects for dried mango are not bad. Mango could become a common snack, as in South Africa, where it is widely available in supermarkets, fruit and vegetable stores and even in convenience stores at petrol stations.

### 3.2.2 Regional market for dried mango

At present, export of dried mango from Mali to the West African coastal region is very limited. From Burkina Faso, dried mango is exported to this zone mainly by Gebana Africa and Wouol, an association of 1500 mango producers in Burkina Faso, one of the country's largest suppliers of dried mangos. They estimate export to the region being around 30-50 tons yearly. Also dried mango from Mali (e.g. from USISS) could find a way to the West African coastal region including Senegal (see chapter 3.2.4).

### 3.2.3 International market for dried mango

Dried mango is part of the larger market for dried fruits. Dried fruits are used on itself as a snack, often mixed with nuts, or as ingredients for breakfast cereals, yoghurts, bakery products, chocolate and muesli snack bars. In 2006, 731,000 tons of dried fruits were imported worldwide for a total value of \$1.3 billion. Developed countries were responsible for 70% of the trade, with Germany being the largest importer (UNCTAD Trade Map 2008).

Dried mango is a very small part of the market for dried fruit, and in fact it is so small that there are no trade statistics available for dried mangoes. Even compared to other tropical fruits, such as banana, papaya and pineapple, it is small because it is relatively unknown and expensive. As a result it is a small part of their business for most traders in tropical commodities; even those specialized in dried fruits and nuts. Mango is mostly traded in pallets of 700-800kg as apposed to containers. As such the market for dried mango is a

niche market. The size in individual markets is measured in tens of tons, and the total size of the market in Europe is estimated between 300 and 500 tons per year. As Latin America and Asia produce their own mango, the European market is the main international market for Africa.

Although the demand for dried mango might be small, it is growing. As part of the trend towards eating dried fruits for health reasons, dried mango is gaining popularity as a snack. Furthermore high prices and thus good margins can be achieved in this segment which makes it an interesting market. Mango dried using solar energy could have an additional marketing advantage in Europe where growing groups of consumers buy green. Nevertheless most Europeans are still not familiar with the product. Switzerland has been mentioned as a relatively large market of dried mango. Gebana AG in Zurich indicated it imported around 300 tons of gas dried mango from Burkina Faso in 2007, also mainly through the above mentioned Wuoul producer association. In addition the UK, Germany and Italy were mentioned by importers, agents and packers as important and growing markets.

According to Netherlands Centre for the Promotion of Imports from developing countries (CBI, eg 1995) the bulk of dried fruits are imported by specialized agents who locate produce, check the quality and organise shipment, and importers, who store the goods before they are sold to packers and industrial users. This appears to be even more the case for dried mango because it is such a niche product. As a result it is not cost effective for most packers and processors to devote resources and time to direct sourcing of dried mango and even importers often use agents. Processors and packers may do some limited conditioning of the product and repack it in small plastic bags of 200 to 300 gram for the retail. Some carry their own brands while others pack and sell under the retailer's brand. Some packers do source directly or are even involved in production<sup>7</sup>.

The food industry tends to buy their dried fruits from importers, and is seldom involved in production and procurement at source.

#### *3.2.4 Constraints and options*

As indicated above, the local demand for dried mango could further develop, but with higher volumes price levels could fall and profitability decrease. Good marketing could help to increase the local demand. Furthermore packaging could be improved. The present poly-ethylene bags do not show well the content and have no moisture barrier which decreases the shelf life of the product to 6-8 months. Presently HELVETAS flies in around 10.000 high quality multilayer<sup>8</sup> polypropylene bags yearly with personal luggage, but if volumes increase cheaper options for transport could be used.

For the regional market the situation is comparable. Presently the export of dried mango to the West African coastal region is very limited, but potential exists and could be materialized organizing transport and packaging. Unlike the situation for dried meat, transport of fresh mango is much more difficult than transport of the dried product. This makes it easier to exploit the better conditions for solar drying in the Sahel region. Yet similar regional trade barriers as for dried meat hamper export to the region (see paragraph 3.1.4).

Although international demand for dried mango is still small, it is growing. Sun drying, as an environmental friendly technology, could add market potential. Simultaneously there is a shortage of consistent, reliable supply which makes it difficult for packagers and traders to develop the market further. To produce for the international market specifications of

<sup>7</sup> Mavedeniz sells organic dried mango in German health stores under the brand 'Morgenland' having set up a drying factory in Sri Lanka.

<sup>8</sup> Pure polypropylene is difficult to seal. Two- or three-layer combinations of polyethylene and polypropylene are mostly used to combine good sealability of polyethylene with good moisture barrier of polypropylene.

consumers and importers should be satisfied (see annex 5). Sri Lanka, Thailand and South Africa have been named as important production countries that have managed to set up reliable production facilities.

Nevertheless, there is space for new African reliable suppliers, especially those that can produce organic fruit of consistent quality that meets the demands of consumers and packagers/processors. They would need to provide at least quantities of around 20 tons per year on a regular basis. Scaling up for the international market would also require the organization/ participation of intermediate traders regularly delivering sufficient quantities of a standardized product to processors.

However companies like USISS, although well adapted to the local entrepreneurial context, are too small to be a structural partner for international importers. Therefore, the option for USISS is to exploit the national market and if possible to associate with other suppliers to operate on the international market.

### 3.2.5 Estimated market review

On the basis of the above mentioned data, an estimation of actual and potential markets for dried mango is summarised table 10. As both dried meat and mango are snacks, main barriers for the development of the local market are very similar and associated with low purchasing power of the population. For regional and international trade barriers are less severe for mango than for meat.

Table 10. Estimated market data for dried mango (1000 US\$/year).

	Local market	Regional Market	International market
USISS sales	5	-	-
Mali sales	15	-	-
Actual market	30	300	3,000
Potential market	100	3000	10,000
Main barriers (see also next chapter)	- low purchasing power - expensive technology and non adapted drying procedures		- low production scale - non adapted technology
		regional trade barriers	international trade requirements

### 3.3 Other dried products

More than 30% of the USISS clients surveyed for the present study mentioned that they also sell dried ginger and slightly less than 30% of the clients sell imported dried coco. Others sell dried pineapple (10%), or dried banana (7%). Most of those products are dried in the sun in the open air.

In 1999 Jensen et al. (Jensen 1999) studied the possibilities for solar drying of food and wood in Ghana. They conclude that prospects for improved solar drying are limited, except for wood. Climatic conditions in Sahel countries are good for solar drying but not for wood production, so for Mali drying of wood seems hardly an option, but as indicated earlier, drying of food products could really constitute an option to further develop.

For some promising products for Mali more detailed information is presented in the next paragraphs.

### 3.3.1 Fish

In Mali an important market for smoked and dried fish exists. The total fresh fish production is estimated at around 95 000 tons (DPN 2005), with a value added of 90 billion FCFA (US\$ 209 million), representing about 4% of the GDP. Most ( $\pm$  80%) comes from the interior Niger delta. Traditionally about 80% of the catch is smoked or dried, but this proportion tends to decrease with increasing availability of ice, which enables better trade in fresh fish. Yet the national market for smoked and dried fish is very important (in the capital Bamako estimated between 15 000 and 50 000 tons of dried fish, van der Pol and Boomsma, 2007). All fish is dried or smoked in the open air. Most processed fish is smoked (75-80%), the rest is dried.

These data are in line with data from Ghana (1999 study by Jensen), where about 80% of the fish caught and preserved is smoked, 20% (around 20 000 tons of fresh fish) is sun dried in the open air. At the time of that study, improved technology in drying was not identified as promising however because the better hygienic quality of the product would not translate in a higher price.



Figure 8. Testing a mobile USISS type dryer for fish at Dagawomina, Mali

In Mali, use of pesticides is estimated to be necessary after drying in the open air, as the fish is heavily infected with fly eggs. The pesticides cause health problems, frequently mortal, which give the product a bad reputation. Thus, with a growing high-end urban market, a market could develop for a better quality product, dried in equipment as used by USISS (figure 8).

Concerning the international market, FAO (2003) evaluated the market for dried and smoked fish in the United Kingdom. The presence of a large Afro-Caribbean population in the UK ensures a ready market for the product presently (see table 11) and for the foreseeable future. Most of the import comes with non-registered luggage from Nigeria and Ghana<sup>9</sup>.

<sup>9</sup> Assuming that 200 kg of smoked fish arrives as accompanied baggage on each flight from Nigeria and Ghana (35 direct flights per week), the weekly total arriving this way from those two countries is tentatively estimated to be in the order of 7 tonnes or approximately 360 tonnes per annum. In addition there is likely to be accompanied baggage fish from other West African countries on direct and in-direct flights. And there are also imports from France, with at least one importer bringing fish into London from Paris by road. Based on these figures the total quantity of smoked fish imported into the UK is in the region of 500 tonnes per annum.

Table 11. Estimated annual imports of smoked and dried fish from West Africa into the UK (2003)

Type of imports	Weight (tons)
Formally recorded under EC Commodity Code 030549 80 "Other smoked fish including fillets"	40
Formal imports otherwise recorded (estimate)	80
Accompanied baggage (estimate)	360
Other	20
Total	500

The majority of smoked fish is sold to consumers via Afro Caribbean grocery shops and Afro Caribbean restaurants in London. Some importers have their own grocery shops. Retailers are concentrated in certain areas of London. The main consumers in the UK of smoked fish from West Africa are people from West African origin. The main market is in London. Small pockets of consumers exist in other major UK cities such as Leeds and Glasgow. As well as the formal outlets, there is also some trade from peoples' homes.

### 3.3.2 Ginger

In 2004, Mali exported about 1 400 tons of ginger, mostly dried in the open air (FAOSTAT). Production aims at 500 ha to produce around 9 500 tons (Ministère de l'Agriculture, 2005) which be processed to give around 2 400 tons of dried ginger.

The international market for dried ginger is important. Eg Sierra Leone was able to prepare four trial exports in 2006: two tonnes of the Chinese variety and two of the local variety. The product was dried in the open air. Buyers included importers in a total of 11 countries, including Germany, India, the Netherlands, Nigeria, South Africa and the United Kingdom. In 2007 it plans to export 80 tonnes of dried ginger, which requires the processing of 320 tonnes of fresh ginger (International Trade Forum 2007).



Figure 9. Treating ginger before drying in Sierra Leone

In Mali, testing ginger drying for export has not yet started and necessity of USISS type technology instead of open air drying has to be documented.

### 3.3.3 Tomato

Hardly any information is available on the national market for dried tomato. Most processed tomato is used in the form of concentrated tomato from 1kg imported tins. Mali yearly imports around 3 750 tons of the product (FAOSTAT, 2004), but it is not known how dried tomato could substitute these imports.

For the regional market the situation is comparable. Presently there is no export of dried tomato to the West African coastal region, though in a country like Benin, tomato in the dryer northern zone is sold in the wetter coastal zone. This could also be expected between interior and coastal countries in West Africa, but regional trade barriers still exist.

Tomato drying offers good opportunities for the international market. Presently a Dutch enterprise started in Mali to grow tomatoes and dry them with an imported electrical dryer for export to Europe. Their aimed capacity is around 100 tons/year. Although in first instance the enterprise opted for solar drying in the open air, protected by nets, given the dusty conditions in Mali, they opted for electrical drying. For two reasons they did not opt for USISS type protected solar dryer: 1) they considered the capacity of the dryer as too low 2) there was no experience with solar drying of tomato in the various seasons.

### 3.3.4 Fonio

Recently the French Centre for International Cooperation in Agricultural Research for Development (CIRAD) introduced a protected (thus clean) solar drying technology for fonio. Fonio is a much appreciated very fine local cereal, which requires before commercialisation cumbersome cleaning in order to remove the sand introduced after drying in the open air. The dryer (see figure 10), with a capacity of around 300 kg of dried fonio in 24 hours, enables solar drying, even during the wet season. In West



Figure 10 Greenhouse dryer for Fonio, Mali



Africa (Burkina Faso, Guinea, Mali, Senegal) yearly around 500-700 tons of fonio is commercialised.

### 3.3.5 Shallot

Drying of shallot chips, giving a product locally called EST (Echalote Séchée en Tranche ) was at the origin of the development of USISS technology. Presently it is a specialisation of the Dogon area where yearly around 50 000 tons of shallots are produced (PCDA 2007). In 1998 about 2.4 % was solar dried, producing 70 tons of EST (Le Hub Rural, 2002, Mali Agricultural Sector Assessment). Drying is mostly done in the open air, although sometimes mini dryers are used. The USISS technology has been tested recently but due to the cost, competition with open air drying is hardly possible.

### 3.3.6 Shea butter

Improved sheabutter production for export involves drying the sheanuts to stop microbiological activity that would increase the fatty acid content and lead to low quality butter. The international sheabutter market is growing.

Presently most drying is done in the open air, which is cumbersome as the nuts are harvested in the rainy season and should be transported inside a shed every time it rains.

USISS technology is being tested for drying the nuts, giving the advantage of having the nuts protected from rain (figure 11). Furthermore drying times are reduced with over 50%. At moment, given the capacity and costs of the dryer, the technology is not yet feasible.

Mixed solar gas technology has been introduced by UNIDO, but presently is not used because of the high costs (figure 11).



Figure 11. Drying of shea nuts in Mali. Left: Unido mixed drying with heat collection on the roof. Under: USISS type (Innotech) solar dryer under test.



## 4 Conclusions

The USISS enterprise appears to be a typical Malian enterprise, with a diversity of activities, mixing business and personal affairs but healthy and adapted to the context it has to work in. As a small collaborative enterprise, relying on its own resources and without the need to hire much additional labour, USISS is able to survive under uncertain and unstable socio-economic political and juridical circumstances. Analysing the solar drying part of the activities and their social and environmental impacts during the life cycle of the products gives a good, but yet incomplete picture of the enterprise. On this basis various options and constraints are identified for USISS. In a subsequent paragraph conclusions are presented on more general policy aspects related to up-scaling of solar drying as a privileged technology for food processing under Malian climatic conditions.

### 4.1 The USISS enterprise

With respect to costs and benefits of solar drying by USISS the following four conclusions are drawn:

*1) Low margins, but a stable enterprise*

Being a small local enterprise well adapted to the entrepreneurial context in Mali the margins on drying are low, but stable and slowly increasing. The growth expectations mentioned in the loan document were not met, however, continuing such an enterprise in the prevailing context can be considered as a success. A summary of conclusions and recommendations with respect to the use of this type of loans is included in annex 3.

USISS' production costs are relatively high, due to the costs of the solar drying equipment<sup>10</sup>, the high rent for the production site in the centre of Bamako and the relatively high salary costs in that capital. This is compensated by their strong position at the market in Bamako.

*2) Benefits of solar drying are directly shown in conventional CBA*

The conventional analysis shows clear benefits of solar drying with respect to gas drying. The difference in resource use - free solar energy or gas -, is directly translated in the costs for inputs and thus in the conventional analysis (7% difference in the costs for drying, 32% in gross margins).

*3) Non conventional environmental costs and benefits are low*

Environmental costs and benefits not accounted for in conventional analysis such as those related to natural resources depletion, CO<sub>2</sub> production or sequestration and waste produced appear to be low (<0.2% of the costs for drying). An eventual subsidy mechanism transferring net environmental benefits for society to private enterprises would hardly influence the margins of USISS and thus would not be effective in promoting the solar drying technology.

*4) Considerable social benefits generated*

The enterprise generates considerable social benefits along the value chain. Valuing these benefits through the revenues generated for low-income groups, the USISS gross margins are multiplied with more than 4 over the entire value chain, producing a yearly income of US\$ 40,000 for these vulnerable groups. In this respect the AREED loan of US\$ 20,000 is fully justified.

<sup>10</sup> In fact, the solar drying technology is not yet mature in its development.

From the market study the following conclusions can be made:

*1) International market*

The international market for dried meat is hardly accessible for USISS because hygienic regulations are difficult to satisfy, even for specialized producers in South Africa. For mango there exist some possibilities, but USISS cannot exploit these on its own with its current capacity of around 400 kg of dried mango being an order of magnitude lower than the quantities of around 20 tons that international traders would require.

*2) Regional market*

For the regional market, especially for the West African coastal zone, there are some possibilities, which are presently not exploited. Also here, in theory, possibilities for dried mango are better than for dried meat, because trans-border transport for fresh meat (on the hoof) is easier than trans-border transport of the dried product. For mango the opposite holds: transport of dried mango is easier and cheaper than transport of fresh mango. Yet the nearby market for dried meat in Kumasi, Ghana, could offer possibilities.

*3) Local market*

The local market is limited by the low purchasing power of the population, but with an increasing urban middle and upper class the urban market, which USISS presently addresses through a network of vendors, constitutes a good basis for the enterprise. Threats could arise from national competitors who have lower production costs, e.g. through external donor support. It is for example questionable if USISS is able to compete with women groups and entrepreneurs in rural areas supported by HELVETAS to export dried mango to the international market. HELVETAS buys gas driers for them, making it possible to continue drying in the rainy season, when mangoes are still available. Yet, gas drying is more expensive than solar drying, especially with increasing fuel prices, and contributes to global warming. The presence of external funds to stimulate gas drying could thus further reduce the value of solar drying. Presently, these producers sell at a relatively low price on the international market, but if they would enter the market in Bamako, USISS probably would have to reduce prices and see its margin shrink.

Both studies lead to the following recommendations for the USISS enterprise if it wants to up-scale:

Going on its own after the international market does not appear to be a viable option. USISS must better exploit the local market. Here, it can build on an existing appreciation from its customer base. As it delivers especially to Bamako, USISS should try to maintain its quality leadership and exploit its network of vendors. It will not be enough to simply increase output. Targeted marketing activities, preferably in collaboration with the vendors, are needed to solidify the 'brand recognition' of its product.

Potential initiatives could include giving away free trial bags to customers or improving the packaging, which is currently not very attractive. To reinforce its product's quality name, USISS would need to improve the quality management during production and the packaging of its product. With these activities, USISS could maintain its position inside Mali and increase its sales of dried mango.

In view of the short mango season, capacity growth in mango demands for diversification. Besides drying mango, and meat, the enterprise could consider to dry other products for which it has a competitive advantage. The national and regional markets for dried fish for example are very important. In Bamako, up to 50 000 tons of dried fish are sold, all dried in the open air exposed to dust and flies. Improved technology such as the solar drying technology applied by USISS could yield better hygienic quality and eliminate the use of

pesticides on the product. Other options to be explored include drying of ginger chips, sheanuts and tomato/gombo.

Regional demand for dried mango and meat could be explored, eg contacting traders from the markets in Ghana.

Aiming at international markets, USISS could consider to join with other processors (like the women groups supported by HELVETAS in mango drying) in order to participate in the large scale transactions required in international trading and to profit from donor support enabling these transactions.

To exploit opportunities, ie investing in networking, cheaper technology and sales increase, the enterprise would need to improve its managerial capacities, especially with respect to the financial management e.g. through stimulating its staff to participate in coaching and training programs. Furthermore, in order to gain access to cheaper drying technology, USISS could try to join in programs for technical development, eg. via the regional Chamber of Agriculture or via the national R&D institutes.

With all strategies for growth however, it should be noted that the entrepreneurial culture in Mali in particular favors small and informal businesses. Hiring supplementary staff with the still very low and uncertain margins from drying, salaries and associated social obligations could easily become an extra burden to the enterprise in case of short falling sales. The general management capacity, which is sufficient for the small enterprise USISS presently is, would also constitute a constraint for growth. Past decisions on loans for equipment showed to be economically ineffective for the enterprise.

#### **4.2 General policies for up-scaling of solar drying**

A number of policy domains could be addressed to promote solar drying technology in a more general way.

##### *1) Subsidies and taxes and other direct incentives*

Direct subsidies and taxes could be motivated if they partly transfer benefits or costs for a larger society to individual enterprises. For instance the considerable social benefits that USISS generates as a processor of agricultural products could justify a subsidy or at least credit facilities to stimulate its growth. The low non-conventional environmental benefits do not justify subsidies for environmental reasons.

##### *2) Transport and road barriers*

Although formally trade barriers do not exist in West Africa, in practice road blocks and uncertainty on transport make it difficult to fully exploit the better climatic conditions for solar drying in the Sahel region for export of dried food products to the West African coastal zone. Minimizing road blocks and administrative procedures would help in this respect.

##### *3) Organization of value chains*

Access to international markets requires reliable delivery of relatively big quantities of a stable quality. These conditions are hard to fulfil in Mali.

Helping entrepreneurs in realising traceability, in guaranteeing quality, in organising primary material suppliers, in obtaining investment and trading credits, these are part of the well known package of measure to improve access to markets for producers and processors in the region. Organization of good packing material is another constraint to be dealt with. For all food processing in Mali, so also for solar drying, the availability of proper packing material is hampering development of local, regional and international markets.

#### *4) Knowledge and innovation needed*

While solar drying would be a cost-effective way of drying in a hot and dry climate as in Mali, the technology is not yet well developed for the local conditions. Solar drying equipment is largely based on imported material and more expensive than needed if local material would have been used. Development of semi-industrial drying equipment seems still in an amateur stage.

Solar drying techniques also require adaptation for specific products, weather types, time of the day and season. For conditions in Mali hardly any experience is available. This is a main reason why in Mali mango is mainly dried with gas. In Africa, in depth knowledge on drying is available only for some major export crops like cocoa, coffee and tobacco. For local market products much more systematic development of knowledge on drying procedures is needed to scale up solar drying. This could be done through public private partnerships in R&D.

Solar drying enterprises like USISS are hardly assisted with knowledge on drying techniques and on equipment and its costs. For potential entrepreneurs guidance in the above mentioned two areas of technology development and adaptation of procedures to local weather conditions is essential.

Like for small scale solar drying, knowledge on industrial solar drying under Sahel conditions is not well developed. It constituted the main reason for the Dutch tomato drying enterprise to opt for the installation in Mali of a large scale electrical flower dryer imported from the Netherlands. Development of knowledge on equipment and procedures for industrial scale solar drying in Sahel conditions is needed. Also here public-private partnerships could be stimulated for R&D work, eg testing larger scale drying equipment with the above mentioned tomato drying company.

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