Guatemala Corn Sheller
Final Report
Team Jon Lee
December 2nd, 2005

Background

In Guatemala, an overwhelming percentage of the population consists of poor, rural, subsistence farmers who grow corn as their main food source. Each growing season, these families must shell, or remove the kernels from, all the corn that they grow for storage and consumption. Currently, this process is completely performed by hand, by the family's women and children, taking up to 10 hours a day during the harvesting season. Inevitably 20% of the corn harvest is further lost every year to pests while the corn is stored before it can be shelled.


Two figures showing how Guatemalan house woman shells corn

Our team seeks to design an extremely low priced handheld corn sheller to assist in this process. The time saved from our corn sheller will free up time to engage in other income-generating work, as well as encourage practices that reduce the amount of wasted corn. Our product may be small, but it can have a large effect in adding value to these families' production.

Market Hierarchy

We focus our business on one single country, Guatemala, where corn is the major food source and corn processing is currently at a very low automation level. But the success of our product will allow us to expand our business to other Central American countries.

Our primary market is subsistence farmers in rural Guatemala who grow and shell their own corn. They represent 62 percent of the population of Guatemala which lives under the poverty line (< $1300 USD per year). In a typical rural household with 6 family members, 800-1200lbs of corn is grown yearly, which requires 100 hour of shelling. We aim at reducing this to 25 hours, saving 75% of their shelling time for other income-generating activities. More remarkably, the reduction of corn shelling time can save that 20% corn loss during storage, thus indirectly leaving more food source for the poor families.

Our secondary market targets large-scale commercial corn farmers, urban families and tourists. There is still a lack of highly automated electric corn shelling machinery in large-scale Guatemala corn farms, due to the extremely high price

(>$10,000 USD), so large farms may also be interested in hand shellers for their employees.

We will incorporate the richness of Guatemala's local culture and history into our product design by adding a fabric cover. This cover not only makes the product more comfortable but also has distinct patterns (e.g. Figure to left) that represent the local culture. The added social values and visual appeals in our product will attract tourists and perhaps urban families.

Figure: Mayan pattern from San Antonio Aguas Calientes, Guatemala

In summary, we segment our market into two major categories. Our main focus is on rural farmers who will embrace the working efficiency and durability of the hand-held corn sheller, while people from urban area will probably have more interest in the social value of the corn sheller that is manufactured in villages.

Manufacturing and Pricing

Our product is made of recycled materials such as used metallic cans and used rubber, which are available locally. We decided to adopt a piecemeal manufacturing model, where interested local Guatemalans fabricate one component of the product (e.g. 500 pieces of 3inch-by-2inch aluminum sheets) and sell them back to us. In this way, we save the cost of renting a large manufacturing space and also directly return our future profits back to the poor families. However, the assembly of the corn

sheller will be done by a central company with small stockrooms which will be rented in villages from local farmers who have additional storage space to spare.

The low cost of the raw materials and the simplicity of the product design allow us to make marginal profits from each corn sheller. The unit cost of our product will be limited to less than 25 cents, and the sale price is set at 50 cent. It will be easy to operate and users can learn from demonstrations given by a salesperson or another user. It is highly durable so that it can maintain working condition for multiple harvesting seasons without repair.

Promotion and Sales

Selling our product through internet or television network is highly unlikely in the rural areas. Instead, corn shellers can be conveniently promoted and sold at local markets which farmers frequent. In order to alleviate the relatively high marginal cost of commercial distribution partners, we plan to hire local villagers as salesmen who will also be responsible for giving on-site demonstrations of the corn sheller. Furthermore, we will include women from villages as our business partners, paid through profit sharing, who will be responsible for promoting and selling our corn shellers within their village. This cuts down the cost which would have to be spent on marketing and advertising, and also increases the value of the women's labor and provides a high potential income.

Competition and Social constraint

Currently, there are no competing products existing in rural Guatemala. However, inaction is a big competitor, as the farmers can simply choose to continue

to hand-shell as opposed to buy our product. Thus, our product's standards need to be very stringent to ensure that it will be preferred over doing nothing. The low cost and unobtrusiveness of our product are geared towards addressing this concern. We are also aware of the potential competition after our product spreads out in the market. Competitors can set up their manufacturing facilities and compete with us for lower price or higher efficiency.

We will react to this situation by quickly building up a strong network with rural farmers, securing a dominating share of the entire market as well as building up a good reputation among rural communities. The partnership with village women not only brings income but also gives them incentives to promote (and also protect) our and also their products. At the same time, we will create new corn shelling models to improve durability and shelling efficiency. We also plan to develop extension businesses, leaving the sales business to rural farmers who have the entrepreneurial spirits to operate sales and services.

Near the end of the harvesting season, house women gather together and exchange their stories when they shell corn kernels. Therefore social constraint does exist as people may be afraid that the introduction of shelling equipment will prevent them from socializing with their neighbors.

To address this, our prototype will be small enough to fit in a woman's palm, so it can be used in the same social context. There are some other social constraints which potentially exist, such as rural farmer's acceptance to new tools. We are going to work with women from rural areas to diminish this gap and improve the acceptability of our new product to the market.

Social Impact

We believe that the hand-held corn sheller has a number of positive social impacts in the rural community of Guatemala. First, it will be the first corn shelling tool that will appear in the rural areas. Although our prototype device is cheap and simplistic, it will be profitable and also beneficial to rural families. In this sense, it should promote intermediate technology in rural areas to improve the efficiency of agricultural work. Next, bringing under-represented house women into our business plays an important role of improving women's social status and adding incomes to their work.

Product Specifications and Architecture

Having established the existence target market through research, our team identified the specific needs of the customers which our product will address. For each of these needs, we established a quantifiable metric by which we can evaluate the finished product. These needs and their associated metrics are:

Customer Needs	Metrics
Cost	Simplicity
Speed	Local materials
Long life	Time to manufacture
Easy to maintain	Cost (manufacturer)
Ease of operation	Reloading time
Comfortable	% Kernels shelled
Portability	Time per ear
Clean kernels	Repairability
Whole kernels	Cycles until failure
Safety	Ergonomic/Flexible
Cultural sensitivity	Learning curve
Promotes technology	Force required
Instills pride	Weight

	Size
	% Dirty kernels
	% Damaged kernels
	Safe
	Instills pride
	Acceptance by users

From these guidelines, a series of product concepts were generated and evaluated. These concepts include a glove sheller with a rough or spiked surface, a cylindrical metal sheller made by using recycled aluminum or tin cans, a handheld automated sheller, and a self-standing automated stripper. There are no other commercial corn shellers available in rural farms of Guatemala, and therefore competitive product benchmarking information is not required. The traditional method of hand shelling is a sole competitor, and since its greatest advantage is social acceptance, it is further considered in the Industrial Design. As seen in the figure below, which rates each design according to the metrics, the integral metallic-can based architecture was the winning design due to its low cost, safety and environmental considerations.

Metrics

Customer Needs

Designs

	Importance	Speed		Repair	Comfortable	Clean	Safe	Tech		Units		Hand		Glove		Standing
		Cost	Long life	Ease	Portable	Whole	Kern	Culture	Pride		Target		Can	Small	Mech	
Simplicity	3	X		X						parts	<10	5	5	4	2	1
Local materials	4	X						X	X	%	>90	5	5	5	4	4
Time to manufacture	2	X								days	<1	5	4	3	2	1
Cost (manufacturer)	4	X								USD	<.50	5	4	3	2	1
Reloading time	3		X		X					sec	<5	2	2	2	1	5
% Kernels shelled	4		X						X	%	>95					
Time per ear	2		X							sec	<10	1	3	3	4	5
Repairability	1			X	X					-		3	1	2	5	3
Cycles until failure	5			X						cycles	>500k	1	3	3	5	5
Ergonomic/Flexible*	5				X	X				-		1	3	3	4	5
Learning curve	1				X					hour	<1	5	5	5	3	3
Force required	3					X				N	<10	1	2	3	4	5
Weight	2						X			kg						
Size	2						X			cm^3						
% Dirty kernels	1							X		%	<10	5	5	5	4	3
% Damaged kernels	4								X	%	<5					
Safe	4									%	<1	3	2	2	3	4
Instills pride	3							X	X	-						
Acceptance by users	5							X		%	>75	5	4	4	2	1
Final scores												**136**	**146**	**141**	**136**	**145**

Important ↔ Unimportant

The figure shows the correlation between each customer need and their metrics. The 5 proposed design concepts are listed on the right and a score is assigned for each metric. The final score for each design is arrived at by multiplying the rating by the importance of the metric and summing. The “Can” design has the highest score.

Industrial Design

The corn sheller is a user-driven product, rather than a technology-driven one, and thus, the industrial design process focuses on the user-machine interface. To address the competition of traditional hand-shelling, which carries great social significance, we needed to truly differentiate our product and ensure its acceptability within the same context. First, we reduced the size of our sheller so that it can be used in the same community based environment and in the same posture as the hand method. We also added a fabric backing both to increase comfort and to display local designs, which would heighten the emotional appeal of our product.

The design is assessed by generating a performance chart. Here we present the product's chart that is composed of 5 categories. Each quality is given a performance rating with a detailed explanation attached to it. The performance rating is the quality of the performance that our product should have rather than its level of importance. For example, our product is made out of metal, which is considered very durable, but durability is not a high level of concern for this particular product.

Category	Rating	Explanation of Rating
1. Quality of User Interface	5	Usage is simple and intuitive. The shape of the product conf to that of hand and corn, thus adding more comfort. Safety i is well considered since all dangerous parts are concealed.
2. Emotional Appeal	4	Aesthetic design is appealing. Locally available & low cost cloth backing for decoration and protection.
3. Maintain-ability	N/A	This is an integral design. Maintenance is not a high level of concern, but the robustness of this product is high and cleaning requires nothing special.
4. Appropriate Use of Resources	5	All materials are locally accessible; very high durability and low manufacturing cost. Recycled materials are used in favor of environment protection.
5. Product Differentiation	4	Our product is definitely unique; nearly no precedents have appeared in rural area of Guatemala before. Competition is low. It's easy to distinguish a corn sheller from bare hands.

Brand

Our product's name will be MásMaiz, which is Spanish for "more corn." Our logo incorporates the motif of a Mayan temple, many of which can be found in Guatemala. The local rural population is predominantly of some Mayan ethnicity, and we hope they will identify with our product on this level.

Finances

Price is an essential consideration in the design of the corn sheller. The sheller needs to be cheap enough for a rural Guatemalan farmer to afford. The target price is 50 cents, which means that the cost to manufacture should settle around or under 25 cents. The challenge is mitigated by the use of recycled materials, which all but make material costs negligible. The majority of the cost will therefore come from salaries, especially the sales and management portion. Some fixed allowances were allotted for the operation, which are independent of the number of shellers made. Thus, the more shellers that are made, the cheaper they will be per unit.

The materials used to manufacture the sheller are the can and the cloth backing. While most workers will probably own a machete, they will have to be provided or loaned pliers and a punching tool. Costs for the tools are calculated based on an estimate of the number of units the tool can last. The labor, as discussed in another section, is done in a piecemeal fashion, which means that the cost per unit is fixed. Five cents are allotted for the labor of each sheller based on time and wage estimates. Sales and management are a slightly more complicated matter. With the profit sharing business model where the local women would take part in the operation,

the sales and management salary is slated at 50% of the total cost. This ensures that a significant portion of the profits goes back to the women who are integral to the process. Ideally, it would also build a highly lucrative partnership, and lubricate efforts to expand into extension businesses. Allowances were allotted for the training of local workers, inventory space, marketing, and transport of units to other villages. The estimates are generous, but nevertheless will make up for unforeseen costs.

A projection was performed through 2010 using data from the cost model. It was projected that sales would begin slowly, spike quickly, level off, and then begin rising slowly again. The price was fixed at 50 cents. The projection estimates that about 100,000 units will have been sold by 2010. The total net profit over this period is over $20,000, meaning that the operation is easily self-sustainable. More importantly, over this period more than $15,000 recycles back into the community, especially with the workers, saleswomen, and managers. Furthermore, the profits will slowly be phased to the local women until eventually they are completely autonomous and claim all of the profit.

Business Model

As Paul Polak pointed out, any product, no matter how cheap, that does not create additional revenue and pay for itself after some time, will not be of interest to people for whom capital is extremely limited. Currently, corn is placed in temporary storage while still on the cob, often in the eaves of houses, for some time after it is dry and during this period approximately 20% of it is lost to vermin. The kernels of corn, once removed from the cob, can be more easily stored in a safe manner, due to

their smaller size. Our product will make the shelling process easy enough to be done soon after the corn dries so that the kernels can be safely stored and the 20% loss will be mitigated or eliminated. This excess corn can then be sold at a local market to recoup the initial investment of the customer and subsequently generate a profit for the customer.

The materials for the corn sheller will be obtained from the large amounts of waste present in Guatemalan towns and cities. The structural casing of the sheller is formed from a tin can such as those that canned food is sold in. One tin can makes four corn shellers, given our latest iteration of the design process. The rough surface for stripping the kernels is either integral in nature, formed by indenting the surface of the tin can, or modular by attaching a strip of rubber to the tin casing. The rubber can also be scavenged from waste by obtaining worn out bike or car tires. We plan on setting up manufacturing in the largest town in a rural area, likely the village that has a regular marketplace, in order to have access to a sufficient amount of waste as well as to easily reach a large number of rural people when they bring their wares to the market to trade. Should the village not have sufficient waste, we could transport raw materials from a larger village, though this is likely to be prohibitively expensive and a more effective solution would most likely be to redesign the product given the resources available within the village.

Manufacturing of the product will be done piecemeal, by providing local people with the raw materials and, when necessary, the loaned or leased tools necessary to complete a particular step in the manufacturing process. We will then pay them for the completed pieces that they return that meet our standards of quality. If it is

demonstrated to be required, we will take collateral in exchange for the raw materials. The locals can thus generate additional income for themselves when their schedules allow and we can keep cost per unit at a fixed rate as well as avoid the fixed cost of factory rental. While not the most efficient method of manufacturing the corn sheller, the need for high efficiency is significantly reduced by the fact that intense demand for corn shellers will be limited to a specific timeframe during the year, specifically the time frame around the several weeks when corn is being shelled.

As the product is relatively durable and use is sporadic throughout the year, we plan on implementing a "rain-drop" approach to distribution, where we set up multiple independent manufacturing sites that are geographically separated. This is because we envision the product distribution to diffuse out somewhat from the locus of the manufacturing village, though not more than 20 miles due to the limited development of Guatemala's transportation system, and reach local saturation rather quickly. By having multiple separated loci, we can eliminate the need to transport either completed products or raw materials which would be costly and unreliable as well as access multiple locations simultaneously during the periods of heavy demand for the corn sheller (immediately preceding and following the corn harvest). Once the local markets reach saturation, we can branch out into new loci as well as introduce new extension business (see below) to the original locations.

We will be able to effectively branch out into new markets once the original markets reach saturation due to our plan to add local women from the original village to our governing board. Upon setting up in a village, we will recruit women from the town to assist us in establishing ourselves and managing the operations in exchange

for a share of the profits from the venture. As the enterprise develops, they will gradually assume greater control of the local operations, functioning similarly to franchise operators, in exchange for an increased share of the local profits. The reasoning behind this is multifaceted. The women will have a familiarity with the local environment, socially, culturally and politically that we, as newcomers, will not be able to discover as rapidly. Also, as a representative sample of our intended customers, they will offer us invaluable insight into improvements to the original design. By providing their salaries in the form of percentage points of our profits, they become invested in helping the venture succeed and can initially act as salespeople/marketers through their interactions with the female social network that often exists in Guatemalan communities. Also, by providing a source of income and managerial responsibilities for a socially marginalized group, we hope to establish trust within the target community, which will be useful not only in the deployment of the corn sheller within the community, but also for our planned subsequent extension businesses.

Extension Businesses

During the course of developing our product, ideas for several other related business emerged. The most promising three of those concepts are an affordable corn silo business, a business that grinds the waste cobs generated by shelling and a local tortillería that purchases some of the excess corn and makes tortillas for the village. These businesses are effectively the next step in our product development, to be deployed once we begin achieving local market saturation with the corn sheller. They

also are centered around the corn sheller: the silo has a synergistic effect with the sheller with respect to preventing crop loss to pests, the cob grinders use the "waste" output and adds value to it in the form of fertilizer, and the tortillería purchases some of the excess corn generated through the efficiency of the corn sheller. The implementation of these businesses is also facilitated by the previous work we will have done in a given village with the corn sheller. By taking on local women to serve on our board of directors, and functioning as local managers for the corn sheller, we will have built up trust with the village, as well as had some time to determine who the most trustworthy and dependable people in the village are. Since the initial venture, the corn sheller, is also the cheapest to implement, it serves as an ideal pilot program that not only can run at a profit with limited penalties for failure but also allows us to learn more about the culture, social networks, and situational factors and lays the groundwork for the subsequent, larger investment projects. A brief overview of the three additional projects is presented below:

Silo Makers

Given that the corn sheller will mitigate the loss of corn while on the cob due to pests, resulting in an increase of useable corn, there will be a need for proper storage of this corn before it is taken to the market or tortillería and sold or consumed. Thus the market for corn silos that effectively protect the corn from rot and pests during storage will be stimulated, and an opportunity to create a business that manufactures affordable, effective silos will be present. The costs of most silos currently is too high for most subsistence farmers, however the corn sheller will

generate additional income that could be reinvested in a silo which would act in concert with the sheller to further increase the useable amount of a harvest. Also, micro loans could be procured to assist with the initial investment. We believe that this is an entrepreneurial venture that we, along with partners from the community, would be in a good position to pursue, given that our corn sheller has succeeded. The managers/business partners for this venture may be men, rather than the women involved with the corn sheller, since it involves construction. This should further build our support from the community, as it involves another demographic than just the women, and provides them with a new opportunity for employment and additional income.

Cob Grinders

While investigated potential uses for the waste corn cobs, which currently are either thrown away or sometimes used as toilet paper, our group found that ground corn cobs function well as carriers for pesticides and fertilizers. Carriers increase the effectiveness of the added material. With corn cob granules, this is achieved by absorbing the added material and slowly releasing it as the cob granules safely biodegrades. The cobs, in and of themselves, possess few beneficial characteristics for use as insecticides or pesticides (though corn cob ash is a good source of potash, it is poor in nitrogen and phosphorous), but there are readily available materials (manure, urine, compost) that could be added or mixed with the cob granules to provide the needed nutrients. This venture would take previous waste, providing some small amount of additional income for the farmers, add value to it by adding

pesticides or fertilizer, and then sell it back to the farmers who could use it to increase crop yields and subsequently, profits. One potential method for creating fertilizer would be to either use cob granules as bedding for chickens, whose droppings are the richest in terms of Nitrogen-Phosphorous-Potassium content of all animals, or by mixing cob ash with the manure. The purchase of an automated cob grinder, if necessary for this venture, would most likely be facilitated by a micro loan.

Tortillería

First suggested to us as a viable idea by Michael Rosberg, the concept of a tortillería, or shop that sells ready-made tortillas, was something we had originally thought would be too culturally invasive. However, he mentioned that it had, in some cases been successfully implemented. The setup is relatively simple; several women from the community purchase a corn grinder and an automated tortilla maker (currently, making tortillas is done daily, by hand, and can take up to three hours), most likely with the aid of a micro loan, and sell fresh tortillas to the rest of the community for a few cents. This would be an ideal venue to sell the excess corn resulting from the corn sheller to, as they could purchase the corn from other members of the community, add value to the product in the form of making tortillas, and then sell it back to the community for a profit. This would generate income for the tortillería workers, provide an additional venue for the farmers and also save a good deal of time for those who chose to purchase their tortillas instead of making them themselves.

Surprises

People lose, according to Mario, ~20% of their corn crop to vermin, especially rats. This occurs when they store the dried corn-on-the-cob in their eaves. This loss could be reduced or eliminated if the corn were immediately shelled and put into some form of storage, such as a silo. Mario suggested that having an efficient method of shelling the corn, such as the one we are developing, would motivate farmers to shell it sooner, preventing some or all of the waste and allowing the farmer to generate income from more of his crop.

Keeping the price to the consumer low was more difficult and complex than we had anticipated. The original focus of designing for cost was developing a product that could be made with very cheap materials and machining practices, but upon compiling our first financial presentation, it became apparent that the salaries of employees were a major contributor to the eventual cost of the product, thus necessitating a re-evaluation of our manufacturing/distribution system. Currently, we are looking into a piecemeal wage rather than a set per-hour wage, which hopefully will reduce the impact of the salaries on the final cost of the product.

While we knew that Guatemala did not have the same level of material availability or prosperity as we have in the US, the extent of the limitations were not clear until we began looking carefully at our assumptions. For example, while developing the current can-based corn sheller, we had to, at one point, verify that the cans we assumed were available would actually be available in the remote villages we will be targeting (it turns out, fortunately, that they will be, at least to some extent). Similarly, transportation in Guatemala is so radically different from

what we are used to in the US that seemingly simple things such as loading your product into a truck to bring it to the next town must be reevaluated within the context that it is possible that the only road to the next town might be completely wiped out by a rainstorm, hindering the efficiency of a highly centralized distribution and manufacturing structure.

As previously mentioned, we had some difficulties conducting market research. However, from these difficulties we have learned that the response time for contacts is often quite sensitive to changing situations and that the ratio of people we contact who then reply to us is lower than we had expected, both of which necessitate attempting to contact a large number of people earlier on in the process in order to get sufficient replies.

Finally, we were surprised by the limited role engineering played in the development of our product. Once we had gone through all the other aspects of design, such as market research, product specifications, and finance, the actual physical layout and machinations of the device was relatively simple and minor. Though the exact physical design is still pending testing, it will almost certainly be a very mechanically simple device, both to manufacture and to use.