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**Swiss Agency for Development
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5 Year Ex-Post Impact Study

POSTCOSECHA Programme Central America

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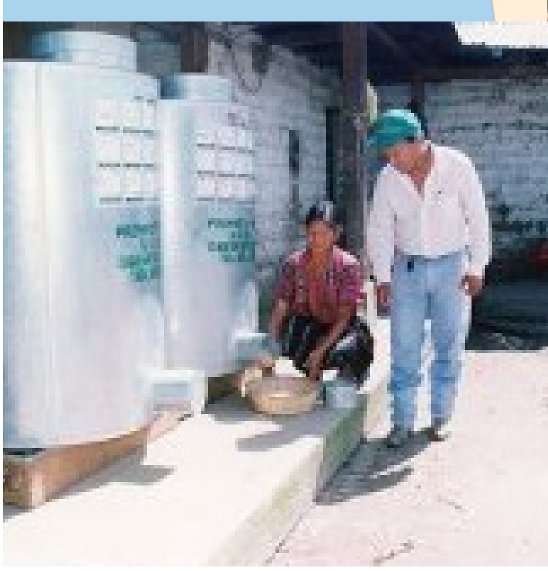


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Martin Fischler, Intercooperation

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Executive Summary

The Postcosecha Programme in Central America was initiated in 1983 by Swiss Development Cooperation (SDC) in Honduras and subsequently expanded to Guatemala (1990), Nicaragua (1992) and El Salvador (1994). Direct support by SDC ended in 2003 but the Postcosecha programme is carried on by national entities. In 2009, SDC mandates a 5 year ex-post impact study of the Postcosecha programme with a double objective: i) to provide facts and explanations for accountability purposes and ii) to identify key information for organizational learning in order to promote the approach in other countries. In line with these objectives the study conducted entails three core aspects: i) validation of existing data on silo production and dissemination, ii) impact measurement of Postcosecha technology on food security, income, livelihoods, price fluctuations etc. at household (silo users, tinsmiths) and aggregate (national) level, and iii) validation and further development of Postcosecha intervention model. The study's approach included three main elements: i) validation and completion of existing data (i.e. silo distribution, tinsmiths) ii) a field survey in the four countries comprising of total 800 silo users and 800 non-users (stratified in three groups) as well as 100 tinsmiths, and iii) interviews with 41 postharvest experts and key informants on agricultural context and policy related issues.

Production and dissemination of metal silos (sustainability of the intervention)

In the time span of 1983-2009, the Postcosecha programme has produced and transferred about 670'000 plane metal silos for postharvest grain storage. The production of plane metal silos has been maintained or even increased after the withdrawal of SDC's support in 2003: 46% of the total silos have been transferred during the period of 2004-2009 and almost half (44%) of them in Guatemala. For 2010, projections in Guatemala and El Salvador are highest compared to previous years. In the case of Guatemala, government programmes aiming at increasing food security applied since year 2000 a subsidy model for silo production and dissemination. This subsidy model is considered as key factor for increased production and dissemination of the metal silo for grain storage. Overall, the development "post SDC programme support" indicates a successful institutionalization and sustainability of the Postcosecha intervention.

Outreach and adoption

Approximately 415'000 rural households have adopted the plane metal silo for grain storage using on average 1.4 silos per family equivalent to about one ton of stored grain (mainly maize) per household. Subsistence farmers have less (1.2 on average) silos storing grain mainly for home consumption whereas farmers with better market access selling a portion of stored grain own more silos (1.7 on average). The transfer channels and modality of acquisition of the metal silos by households have evolved differently in the four countries: Purchase of the silo paying in cash is common in Nicaragua (44%) and especially in Honduras (86%). In El Salvador, recent government programmes hand over silos to farmers "in concession" (54%) while in Guatemala the government is subsidizing the silo production through a contract scheme where the farmers pay only labour to the tinsmiths (about 25-30% of the full cost of a silo). The governmental programmes are likely to affect the market-driven dissemination of silos, especially in El Salvador where farmers refrain from buying if they can expect a "free" silo. The Guatemalan approach seems to be less market distorting and the direct relationship between farmers and tinsmith is mostly maintained.

Impact at household level

Rural households (silo users): The results of the study confirm the positive effects of the metal silo use on rural households in regards to reduction of postharvest grain losses and changes in the use, storage and selling dynamics of grain. Subsistence farmers keep almost the entire production for covering own consumption needs and by using the metal silo they have increased their food security by 30 to 35 days per year. To cover food needs with the safely stored grain (mainly maize) is the most important aspect for subsistence farmers (increased resilience and savings from less need to buy grain in high price season). On the other hand, farmers with market access selling some of their produce additionally benefit from the metal silo by selling safely stored grain later during the season when prices are higher. The additional cash income generated in this case is 90US$/year (or 5% of the average gross income per family of 1800 US$) and equals approximately the actual price of an 18 qq. silo. The study confirms that metal silo users who sell grain have a distinct behavior in regards to timing, selling location and purchaser i.e. more produce is sold later in the season in the village and directly to consumers.

Investments of silo users is in the range of 40-90US$ per year and is significantly higher than for non-users. The Cost-Benefit ratios of the metal silo ranging from 2.3 (subsistence farmers) to 3.5 (farmers with access to markets) show that the metal silo is becoming more attractive in economic terms for farmers selling maize. However, the lack of initial funds to purchase a silo is still mentioned mainly by subsistence farmers as a hindering factor for higher adoption of metal silos.

Finally, the metal silo has a significant impact on livelihoods of staple grain producer households with biggest improvements for subsistence farmers especially in Guatemala. Perceived positive changes are foremost related to availability of food, family income and employment, education and health of children, housing condition, social status in the community and workload of women. However, the metal silo is just one element in a more complex system of the rural household economy and there are many other factors that affect rural households. Technological innovations like the metal silo can only partly offset such macro effects. In particular, increased off-farm employment was frequently mentioned by farmers as contributing factor for improved food security and income. Nevertheless, this study establishes plausible evidence that the adoption of metal silos has improved the ability of individual households to cope with food insecurity and economic stress.

Tinsmiths: A total estimated 800-900 tinsmiths are active in the four countries producing silos in a decentralized manner and at different scales (from less than 20 silos by micro entrepreneurs to thousands by larger family enterprises or associations). Only 27% of the micro-entrepreneurs being mostly farmers indicated production and selling of silos as their main source of income. Consequently, annual gross profits per tinsmith vary greatly according to the size of the silo business: 550 US$ for a micro-entrepreneur (farmer tinsmith, <50 silos/year) up to 5100 US$ for larger tinsmiths business, the latter being more developed in Guatemala and El Salvador. The figures show that the production of metal silos is attractive for farmers as an additional off-farm income but far more for more commercially oriented tinsmiths businesses generating a relatively high income. Consequently, most tinsmith families reported improved livelihood conditions in terms of food security, income and employment, education and health of children, housing condition, and social status within the community. These improvements are more frequent for small and medium tinsmith businesses compared to farmer tinsmiths.

Recent government initiatives in Guatemala and El Salvador for larger-scale dissemination of the metal silos seem to favour bigger tinsmith businesses (individuals or associated). Consequently, a certain concentration process is occurring, i.e. larger and better organized tinsmiths have better access to attractive government contracts (especially in El Salvador and Guatemala) while individual artisan/farmer tinsmiths selling silos directly to farmers are increasingly facing the challenge to get new clients. A similar effect is seen in Nicaragua where silo production by farmer-tinsmiths has decreased over the last five years.

Impact at national and regional scale

Aggregated figures show a total decentralized grain (mainly maize) storage of about 380’000 tons/year by 415’000 rural households (about 2.4 million people) corresponding to a coverage of 21% of staple grain producers in the four countries. The amount of grain saved from loss amounts to 38’000 tons per year (10% of stored grain saved from loss) worth 12 million US$ at current (2009) prices. Including the effect of selling maize stored in metal silos at a premium price, this amount increases to 21 million US$ per year. For the whole period of the Postcosecha intervention (1983-2009), the total accumulated quantity of grain saved from loss is approximately 336’000 tons with a accumulated value of 75 million US$ (historical prices considered). Including the effect of selling at a premium price this amount increases to 90-100 million US$. The density of silos (21% and 35% of staple grain producer households in the four countries and Honduras alone, respectively, use metal silos) reduces inter-seasonal price fluctuations by 15-20% (average all four countries) and by 30-40% for Honduras. Therefore, the decentralized grain storage in metal silos (especially maize) can be considered of national and regional strategic importance in terms of food security and price stability.

In regards to national/regional impact at tinsmith level, for the same period (1983-2009) 12 million US$ of gross profit is generated by 800-900 tinsmiths producing metal silos and other metal products; in addition to approximately 3 million US$ of gross profit for metal sheet traders. The impact is highest for Honduras and Guatemala.

Evolution of the intervention model and implications for replication

The main success factors of the Postcosecha intervention model identified through expert interviews are: implementation through inter-institutional alliances (public-private), availability of an appropriate and high quality technology accessible to smallholder farmers, and investment in training of tinsmiths with a decentralized silo production. Main limitations are related to availability and cost of raw material (i.e. galvanized metal sheets of the required standard). There are important differences in the way the programme has evolved in the four countries after the withdrawal of SDC mainly due to different level of commitment by the governments. In Guatemala and (more recently) in El Salvador a higher level of institutionalization and appropriation by the government can be observed. Governmental programmes have included the technology as an important element of increasing food security applying, however, different approaches (see under outreach and adoption above). In Nicaragua and Honduras, the intervention model could only partially been sustained due to lack of government commitment and institutional weaknesses. Nevertheless, a market for silos persisted (at a low level, though) which shows the importance of fostering a functional market beyond government programmes.

Implications for replication

Current trends (i.e. increased political will in many developing countries and donor agencies to address the issue of food security and improved access to markets by smallholder farmers) provide a favourable environment to initiative postharvest initiatives in many other countries pursuing a two prong strategy: a) decentralized grain storage as an important element for ensuring food security and b) grain storage as a business i.e. improved integration of smallholders into markets. The Central American experience provides sufficient evidence for successful replication. Important elements to consider are: creation of inter-institutional alliances/public-private partnerships, delivery of a high quality product by trained entrepreneurial silo producers, clear targeting/promotion starting with higher potential areas, affordability through differentiated pricing, fostering innovation and client diversification, coordination and facilitation through a body inserted in existing and functional structure (public or private), awareness creation for creating a “postharvest culture” and contribution to creating conducive policy frameworks.

1. Introduction

1.1 Context

In Central America, 47% of the total population of Guatemala, El Salvador, Honduras and Nicaragua or 16 million people still live in rural areas (World Bank, 2008) and 62% of them or 10 million people are producers of staple grains like maize, beans, rice and sorghum (in order of decreasing importance) (Baumeister, 2010). The majority of staple grain producers are small to medium family farm holdings of less than 1 up to 10 ha cultivated land (0.3 to 2.0 ha arable land per head of agricultural population; 2007, FAOSTAT). Between 39% (Nicaragua) and 92% (Guatemala) of staple grain producers possess less than 2.1 ha (three "manzanas"; 1 manzana = 0.7 ha) of land (Baumeister, 2010).

Staple grains, primarily maize and beans, play a crucial role for food security, income generation and livelihoods of the rural population in Central America. Maize is the main staple food whereas beans are an important source of income as well as protein complementing the maize based diet. White maize is almost entirely used for human consumption while yellow maize is mainly used for animal feeds. Average food needs of a typical family of 5.4 persons are estimated to be 810 kg of maize and 240 kg of beans (Baumeister, 2010). Between 45-53% of the national maize production is used for home consumption, the rest is sold. The region imports from intra and extra regional markets only 6% of white maize and 10% of beans (IICA, 2007). Nevertheless, in 2007 a total of 5.3 million people were undernourished in the four countries with Guatemala having the highest (21%) proportion of undernourished people (FAO, 2010).

Postharvest damage (physical alteration caused by biotic or abiotic agents) and loss (difference between total damaged and recoverable damaged grain still fit for human consumption) of staple grains due to insect pests, rodents and birds are a common problem in developing countries. Main insect storage pests of maize are the Larger Grain Borer (*Prostephanus truncatus*), the Lesser Grain Borer (*Rhizopertha dominica*) and the maize weevils (*Sitophilus spp*.). Main loss of stored beans is caused by the bean weevil (*Acanthoscelides obtectus) and* bruchid beetle *(Zabrotes subfasciatus)*. Exact figures of postharvest losses are scare due to the complexity of measurement and wide variation over years and geographical locations. FAO (1993, 1998) estimates storage losses due to insect pests and rodents to be 5-25%. This figure is confirmed for Central America by a two year study conducted in Honduras (Raboud et al., 1984) indicating maize postharvest damage and losses of 12.5% and 8.1%, respectively (average for two consecutive years). Similarly, Abeleira et al. (2008) mentions postharvest losses in beans of 7.4% to 10% in Mexico.

1.2 Programme Postcosecha

Recognizing the importance of postharvest management of staple grains, the Swiss Development Cooperation (SDC) launched in 1983 the "Postcosecha" (Spanish for Postharvest) Programme in Honduras and subsequently expanded it to Guatemala (1990), Nicaragua (1992) and El Salvador (1994). The technology used is a plane metal bin (silo) made of high quality galvanized iron sheets. The silo can be hermetically sealed allowing fumigating the stored grain mainly using pellets containing phosphine compounds e.g. aluminium phosphide, "phostoxin" (Bravo, 2009). The silos are produced by trained tinsmiths in a decentralized manner. Direct support by SDC ended in 2003 but the Postcosecha programme is carried on by national entities.

1.3 Background of ex-post impact study

In line with the increased interest of the donor community in results/impact measurement, SDC has mandated a 5 year ex-post impact study of the Postcosecha programme with a double objective: i) to provide facts and explanations for **accountability purposes** and ii) to identify key information for **organizational learning in order to promote the approach elsewhere.**

The assessment is conducted by a consortium of Intercooperation (lead), Nitlapan (Nicaragua: field survey in four countries) and the Institute for Environmental Decisions/ETH Zurich (scientific assistance). Additional local support was provided by a local consultant (ex-Postcosecha staff). The study attempts to verify the following general impact hypothesis of the Postcosecha intervention:

The production (tinsmith level) and use of the metal silos (mainly by small and medium farmers) causes a significant change in food security and livelihoods of silo producer and silo user households, which in turn contributes to an impact at national level (increase in food security, decrease in price fluctuations).

The study entails three core elements:

i) Validation of existing data on silo production and distribution

ii) Impact assessment i.e. measurement of effects of Postcosecha technology on food security, income, livelihoods, for farmers and tinsmiths (household level) and an approximation of impact attribution of Programme at national level (e.g. food security, stabilizing effect on maize price fluctuations)

iii) Validation and further development of Postcosecha intervention model for its replication.

2. Methodology

The study's approach is based on three main activities:

i) establishment of an inventory of existing data (i.e. No. of tinsmiths, silo production and distribution), its verification and completion,

ii) a field survey in the four countries comprising a total of 800 silo users and 800 non-users (comparison group) further disaggregated in 3 categories (see Annex 1, Figure A1.1) as well as 100 tinsmiths, and

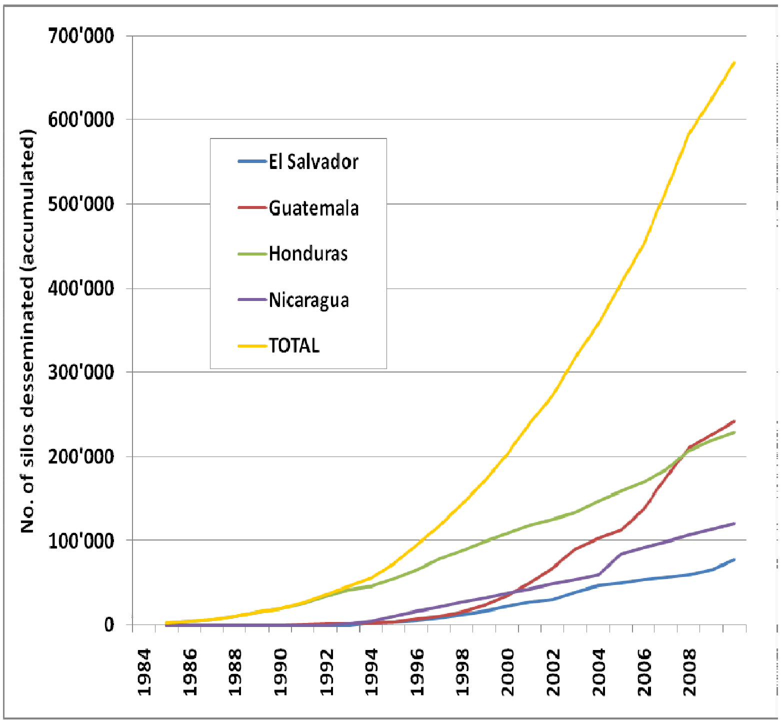
iii) interviews with selected postharvest experts and key informants on agricultural context/policy related issues. Preliminary results were validated in a workshop with key representatives from all 4 countries.

Calculations of aggregated impact at different levels (silo user, tinsmith, and national scale) are based on survey data and additional sources (CEPAL, FAOSTAT etc.). The detailed methodology is described in Annex 6. The results of the study are presented in the following chapters with additional explications given as endnotes ([x]).

3. Outreach, adoption and impact of metal silo

3.1 Production and dissemination of metal silos (outreach)

The total number of transferred metal silos since the beginning of the Programme in 1983 (Honduras) until end of 2009 adds up to approximately 670'000 units with Guatemala and Honduras showing the highest figures (Figure 1). At the end of 2003 (withdrawal SDC), about 360'000 silos had been transferred. In the following 6 years (2004-2009) additional 310'000 silos (46% of total) were transferred with Guatemala accounting for almost half (44%) of them (detailed figures in Annex 1, Figure A1.2 and Table A1.3). Bigger annual fluctuations within a country are explained by larger government initiatives/campaigns causing some peaks (Annex 1, Figure A1.3). The figures show that the production and dissemination of metal silos remained intact or even increased after the withdrawal of the direct support by SDC in 2003.



The current trends indicate that due to larger government programmes aiming at increasing food security at national scale the transfer of metal silo will increase significantly in the coming years in Guatemala (target 2010: >60'000 silos; cf. interview R. Ochoa) and El Salvador (target 2010 and following years: >25'000 silos; cf. interview D. Navarrro). This is less the case for Honduras due to political instability and institutional weaknesses (e.g. lack of existence of a coordination unit besides training institute INFOP). In Nicaragua, the dissemination of silos will be lower despite some recent intentions by INTA to take up again the Postcosecha programme after years of declining activities.

Figure 1. Evolution of transfer of metal silos per country and total

3.2 Adoption of metal silo by rural households

Overall (average of 4 countries), 43% of the farmers surveyed (silo users) indicated to have acquired a metal silo during the last 5 years which is consistent with the silo distribution data (calculation for 5-year period 2005-2009: 38%). Guatemala shows the highest recent adoption of the silo (67% of the silos have been acquired within the last five years (Annex 1, Table A1.4). The average number of silos per producer household is 1.4 with little country differences (range: 1.4-1.7; Annex 1, Table A1.5). One third of the households have two or more silos. Subsistence farmers have the lowest (1.2) number of silos whereas farmers with more maize production (type C) own more silos (1.7). This is an indication that farmers with market access use silos for selling some of the stored grain.

The average number of silos per household is slightly lower than the average of 1.7 silos found by Gladstone et al. (2002) most likely explained by the increased importance of government programmes whereby households are entitled to get one silo only (subsidised/donated). However, these figures also show that the frequently encountered extrapolation "one silo transferred = one beneficiary household" is not fully valid and consequently the total number of directly benefitting households and population (2.4 million; Annex 2, Table A2.2) is lower than extrapolated 1:1 from the number of silos transferred.

The silo sizes most frequently encountered are 18 and 12 quintals (820 and 545 kg, respectively), which together account for 84% of all silos transferred (Annex 1, Table A1.6). In Guatemala, due to smaller sized houses and the subsidy programme, the 12 quintal silo is mostly encountered (78%) whereas in the other three countries farmers opt mainly for the 18 quintal size. Combining the number of silos per household, the silo size and adjusting for actual use of the silos (95%) and average annual filling capacity (90%) as indicated by the farmers (Annex 1, Table A1.7), the effective average quantity of grain (>90% maize) stored annually in metal silos is approximately 900-1000 kg per household (Annex 2, Table A2.2). Differences between countries are small. This quantity is in line with annual family maize consumption needs of approximately 800 kg leaving a surplus for selling. However, differences in the proportion consumed vs. sold vary for farm types (see chapter 3.3.2).

Most farmers either purchase the silo directly or through a government programme (Table 1). Direct purchase dominates in Honduras while government programmes account for half of the silo acquisitions in Guatemala and El Salvador. In Nicaragua and especially in Honduras most farmers purchase the silo paying in cash[1] (Table 2). In El Salvador, recent government programmes hand over silos to farmers "in concession" under the condition that the silo is used for 15 years (e.g. project SICTA network[2]). In Guatemala the government is subsidizing the production and dissemination of metal silos through a contract scheme (Box 1). In Nicaragua, besides direct purchase the NGOs play a relatively important role.

Table 1. Transfer channels of metal silos (%)

Country	Direct tinsmith	NGO	Govt. programs	Other	Total
Guatemala	23	13	53	11	100
El Salvador	43	6	45	6	100
Honduras	86	4	2	8	100
Nicaragua	44	25	12	19	100
Total	43	12	33	12	100

Table 2. Modalities of silo acquisition by farmers (%)

Country	Paid cash	Subsidized	**Donated** (or concession)	With credit	Others	Total
Guatemala	20	75	4	<1	<1	100
El Salvador	45	<1	54	<1	1	100
Honduras	86	<1	4	9	1	100
Nicaragua	57	4	23	13	3	100
Total	46	28	20	5	1	100

In-depths analysis of factors influencing decisions to acquire a metal silo show that the probability to buy a metal silo reduces with increasing age of the household head, meaning that younger farmers are more likely to adopt a silo. In addition, a larger share of own land in the farm crop land and higher household maize self-sufficiency increased the probability of metal silo adoption (Bokusheva et al. 2011). The smallest farms obviously do not produce enough grain for storage and therefore are unlikely to purchase a metal silo.

The decision to acquire a metal silo is mainly taken by men (67% husband or son), followed by both (20% husband/wife) or by the women only (11%), the latter being mainly female headed households (analysis of all households). Answers from women respondents only (25%) indicate that the decision to acquire a metal silo is taken by men (44% husband or son), women (29% wife or daughter) or both (25% husband/wife).

The main reason indicated (66%) for acquiring a metal silo is the problem of postharvest loss of grain and consequently 73% of the farmers reported the loss reduction of stored grain as the main advantage of using the metal silo (Annex 1, Table A1.8). Most (88%) of the farmers indicated no disadvantages of using the metal silo. The non-adopters indicated as main reasons for not acquiring a metal silo the lack of funds (68%) and not producing enough grain for storage (9%).

Box 1. Metal silos in Guatemala: A case of smart subsidies?

Background: The government of Guatemala declared the reduction of postharvest losses of staple grains as priority within a national strategy to increase food security and improve the livelihoods of the most vulnerable population living in extreme poverty. In 2000, the Ministry of Agriculture (MAGA) introduced a subsidy model focussing on mass distribution of plane metal silos to poor farmers. In 2009, the Government signed a three year agreement with the European Union as part of the Strategic plan to combat malnutrition in the vulnerable rural population. Funds provided by the EU will finance to a large extent the silo subsidy programme during the period of 2010-2012.

How the subsidy model works: The model is based on the State financing the zinc sheets including its transportation from point of origin to the tinsmiths which constitutes about 62% of the total costs for metal silo fabrication (public procurement procedure for zinc sheet supply). Postcosecha staff then organizes the distribution of zinc sheeting to contracted tinsmiths in the provinces (individuals or associations) who receive the zinc sheets for free and in turn are allowed to charge the farmers for labour and utility only - currently about 170 Quetzals or about 22 US $ per silo of 12 quintals (only this silo size is subsidized). This is about 25-30% of the commercial price. The tinsmiths' net benefit is about 5-10 US$ per silo which is less than he would earn by selling the silo outside the subsidy programme. However, this is compensated by a higher an assured sales volume of silos. Importantly, in this scheme the direct relationship between tinsmith and farmer is maintained allowing the tinsmith to pass proper instructions to the farmer about the use and maintenance of the metal silo. In addition, the tinsmiths are not directly affected by metal price fluctuations as occurred in more recent years.

Selection criteria for benefitting farmers: Today, more than 80% of the silos are disseminated through this scheme which is only accessible for small (poor) farmers according to defined criteria. These are: rural families with children living in poverty and extreme poverty residing in impoverished communities (according to the National Plan for Poverty Reduction), families producing staple grains, families who have been victims of natural disasters (floods, landslides, earthquakes).

Appreciation of subsidy model: As every heavy subsidy intervention by the State, there is the risk of market distortion. In some locations the commercial demands for silos has actually decreased which is affecting tinsmiths producing silos outside the subsidy programme. However, in the current context in Guatemala where food security for the rural population is an overarching issue, the subsidy programme allows a mass dissemination of metal silos which would have not been possible otherwise. The dissemination figures in Guatemala and the results of the current study confirms that the subsidy programme in Guatemala has been a mayor factor for improved food security situation of poorest farmers.

"*The Postcosecha Programme has high social and economic benefits for the rural population, at low cost. Many rural families are learning postharvest methods. Families are more food secure now and have healthy food; in addition of having created rural employment and income especially for tinsmiths. Small subsidies for the promotion of the metal silos are justified as they have big benefits, without being paternalistic*." (Carlos Anzueto, former director of "Unidad de proyectos de la cooperación externa y fondos fideicomiso" in Guatemala). For details of the subsidy model see Annex 10.

3.3 Impact of metal silo on rural households

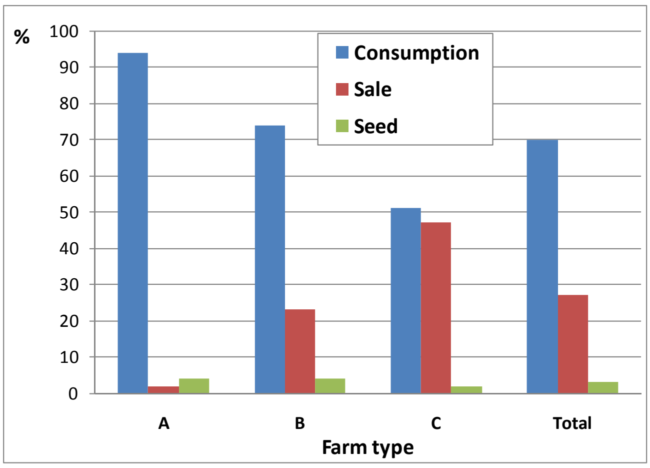
3.3.1 Reduction of postharvest losses

The Postcosecha programme mentions that a major driver for adoption of the metal silo is the reduction of postharvest losses of stored grain to a level of almost zero. The survey results confirm that only 6% of silo users reported losses of maize stored in metal silos but at a low scale (4% on average, based on farmers reporting losses; Annex 1, Table A1.9). No farmer indicated losses higher than 20% of maize stored in metal silos. These results confirm that a total loss of maize stored in metal silos due to inadequate silo management (storage of insufficiently dried grain, insufficient fumigation etc.) does not occur frequently. On the other hand, 21% and 11% of the farmers reported loss higher than 10% and 20%, respectively of maize stored in other storage systems (albeit total loss was mentioned in two cases only). These results confirm that farmers see the keeping of grain in the metal silo as a safe storage method (also confirmed in the study by Gladstone et al., 2002).

One important aspect for the effective control of storage insect pests is the treatment of the grain with a fumigant once the metal silo is filled. An aluminium phosphide product, generally known in Central America as *Phostoxin* or *Phosfamina* has been effectively used for grain fumigation. Some concerns were raised due to misuse of this product (see Box 2).

3.3.2 Storage and use of stored grain

In order to understand how the stored grain is used, it is important to know the quantity stored and the storage systems used by the different farm types. Of the total harvested maize, farmers sell about one quarter right after harvest with little differences between silo users and non-users (Annex 1, Table A1.10). Silo users store about half of the maize harvest in metal silos (average of 53%; range: 40-64% for the 4 countries) and the remainder in other storage facilities[3]. However, subsistence farmers (type A) sell less grain at harvest (8% for both users and non-users) and consequently store a higher portion of grain (silo users store 78% in metal silos and 14% in other storage systems; non-users store 92% in other storage systems). Bigger farmers (type C) sell almost 40% at harvest and store 60% of which two third is stored in metal silos (Annex 1, Table A1.10).



The use of stored maize in metal silos is mainly for own consumption (70% on average), then selling (27%) and seed (3%) (Total in Figure 2). Subsistence farmers (type A) store grain almost entirely for own consumption (94%) whereas farmers with market access (type C) sell almost half of the silo stored grain. Selling is most important in El Salvador where farmers with access to market sell 60% of the grain stored in metal silos (Annex 1, Table A1.11). The differences between farm types in selling of maize is important and needs to considered for the analysis of maize selling and price dynamics.

Figure 2. Use of maize stored in metal silos according to farm type

Box 2. Misuse of aluminium phosphide (grain fumigant) – is it a problem?

Use of aluminum phosphide: A product, generally known in Central America as *Phostoxin* or *Phosfamina*, is used as fumigant in grain storages. The product has been on the market for the last fifty years and due to its effectiveness, low costs and ease of use, has been widely accepted among small farmers as well as for industrial use. The Programme Postcosecha has also promoted the use of aluminum phosphide to fumigate grain in the metal silo. The programme has put emphasis on proper training of farmers in the use of this product.

Misuse of aluminum phosphide: Misuse of this product for committing suicide has been reported. According to statistics in Guatemala 92 cases of poisoning due to the ingestion of *Phosfamina* tablets product have been reported for the period of 2006-2010. In Nicaragua, 1872 cases of intoxications with aluminum phosphide were reported for the period of 1995-2004 of which 91% were intentional. A ministerial resolution (No. 55-2004) was issued in Nicaragua in 2004 to prohibit the importation and sale of the product without prior authorization. This led to an increase in price for the product. Nonetheless, the product is still being widely used by farmers who obtain it through a number black-market channels.

Assessment: To assess the danger and magnitude of phosptoxin misuse, it must be noted that between 60% and 80% of suicides can be attributed to the ingestion of agrochemicals others than phostoxin. The fact that the product distribution was forbidden in Nicaragua (and regulated in El Salvador) has not lead to a reduction in the number of poisonings. The industrial use of *Phosfamina* is overseen by specialists that are appropriately-equipped and trained by the commercial companies. However, the use in large quantities in big stores etc. cannot be compared with the small quantities used in metal silos.

Conclusions and recommendations: *Phosfamina* is a very popular product that is in great demand by small farmers as well as for commercial and industrial use. Attempts to control or restrict its sale as is the case in Nicaragua did not yield the expected results. In fact, the results have been the opposite and have led to it being traded on the black market at prices up to ten times higher combined with grain losses due to the lack of a cheap fumigant for small farmers.

There is significant awareness among wholesale distributors and importers that it is important to instruct users on how to apply the product correctly. There is little research available for new product development or to confirm the validity of alternative products. The most recent developments include the use of a method based on controlling postharvest pests by simply eliminating the oxygen (e.g. by burning a candle in the hermetically sealed container). In Central America, this method has just recently been introduced and little practical information is available.

The potential danger from inappropriate use of *Phosfamina* tablets to commit suicide does exist but the same applies for most other agrochemical products. However, and more importantly, very few occupational accidents have been reported from applying the product.

In light of the above, the recommendation is that sales to the public should not be restricted, particularly not to the small grain producers. The sale of the product should however be accompanied by some measures (only selling to adults by authorized dealers in limited quantities, reporting of sales to Ministry of Agriculture, appropriate training of farmers for appropriate use etc.) For details on the assessment on use of aluminium phosphide see Annex 11.

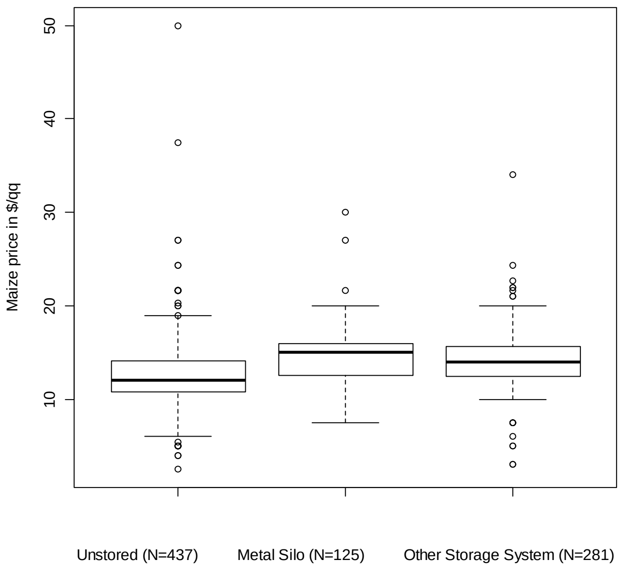
3.3.3 Selling pattern of maize by farmers and effect on prices

Marketing of the maize and bean production is important in Central America. The region only imports from intra and extra regional markets 6% of white maize and 10% of beans (IICA, 2007). However, imports can be higher in particular years of low production (e.g. in the case of Nicaragua for 2004, 2006 and 2007) and has increased during the food price crisis starting in 2007 (Pérez, Barrios, & Pavón, 2010)[4]. Due to seasonal behaviour, maize prices are usually low during the months after harvest (starting mid-August till February) when the offer is high and reach peaks before the beginning of the next harvest (May to beginning of August) when the available grain on the market is getting more scarce (Zappacosta, 2005)(Pérez, Barrios, & Pavón, 2010) (See also Annex 5A). Farmers who are able to safely store grain can potentially benefit from these price fluctuations (Florkowski & Xi-Lling, 1990). Thus, additional direct income and/or savings due to the use of the metal silo is mainly achieved through i) savings due to avoided loss of grain, ii) savings due less need to buy maize in high price periods, and iii) selling stored grain later in the season when prices are higher[5]. In addition, the capacity to withhold a significant amount of maize from the market after the harvest by storing and selling it later during high price periods is likely to have a price stabilizing effect (see chapter 3.4.2).

Table 3 shows relative frequencies (in %) for selling location, purchaser as well as main month of selling. It shows that stored maize is rather sold in the village (67%) compared to farm-based selling (52%) of unstored maize. While unstored maize is mostly (76%) sold to local traders (middlemen), direct selling to consumers is most important (50%) for silo stored maize. With regard to selling location and purchaser, maize stored in other systems ranges in between unstored maize and maize stored in metal silos. It is also mainly sold in the village or the city (capital of department), but is less often sold directly to the consumer than metal silo stored maize.
Also the time of selling is significantly different: The main selling month of unstored maize is shortly after harvest, 79% of the farmers indicated the period from November to February as the main selling time. In contrast, metal-silo stored maize is mainly (73%) sold from March till July which is the most critical period before the new harvest when selling prices are highest. Maize stored in other systems is sold on average after unstored but before metal silo stored maize.

Table 3. Location and time of selling and purchaser (analysis for silo users[6])

Selling Location	**Unstored Maize (N=225)**	**Metal Silo Stored Maize (N=123)**	**Maize stored in other system (N=89)**
Farm	52%	24%	24%
Village	39%	67%	57%
Road	4%	1%	1%
City (Capital of department)	4%	7%	11%
Other	2%	2%	7%
Pearson's Chi-squared test statistic 49.26***			
Purchaser			
Local traders (Intermediaries)	76%	41%	54%
Direct to consumer	20%	50%	34%
Others	3%	9%	12%
Pearson's Chi-squared test statistic 56.12***			
Month of Selling			
August- October	12%	7%	14%
November-February	79%	20%	36%
March-July	9%	73%	50%
Pearson's Chi-squared test statistic 302.85***			



Price levels show that stored maize generates in general significantly higher prices than unstored maize (Figure 3, details in Annex 1, Table A1.12). However, price differences were not significant for Honduras which could be a combined result of price stabilizing effect and government policies (see chapter 3.4.2) Moreover, prices for maize stored in metal silos seem to be slightly higher than for maize from other storage systems. This is a likely to be a combined effect of different selling period and higher quality of grain stored in the metal silo.

Figure 3. Maize price by storage system (in US$/quintal)

The results from regression analysis show that maize price levels in El Salvador and Nicaragua are lower than in Honduras and Guatemala (Annex 1, Table A1.13). It shows furthermore, that if these country specific effects are considered, maize stored in metal silos leads to an average price mark-up of 1.85 US$/quintal (equivalent to 41 US$/t), while maize stored in other storage systems generates a price mark-up of 1.46 US$/quintal (32 US$/t) compared to unstored maize.

Similar findings are reported by Hannes (1991) indicating that silo users in Honduras sold 66% of stored maize before the new harvest during the high price period from May-August at an average of 8.85 US$/quintal (farm gate prices 1991). Non-users sold 50% of the maize shortly after harvest i.e. from November-December at an average of 7.00 USD/quintal (hence exactly the same nominal price mark up of 1.85 US$/quintal) and the rest is sold more distributed throughout the year. The same study also confirms that silo users and non-users are selling to different clients. Silo users sold 74% of the maize to family members or within the village whereas non-users sold the bulk (87%) of maize to middlemen or on the market.

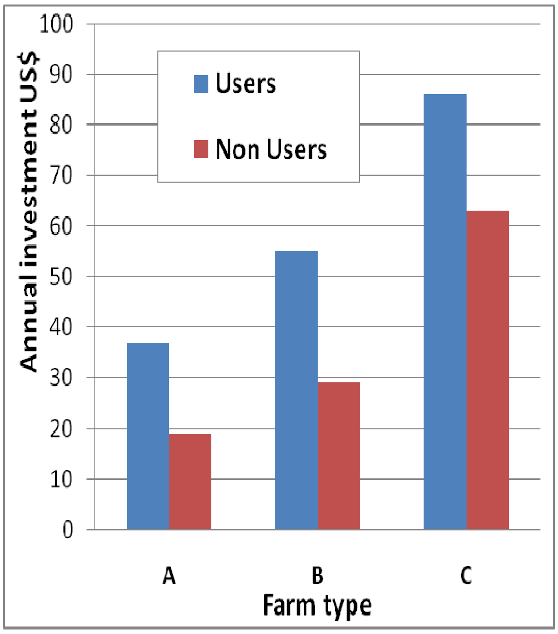
Using the above results on maize selling and price dynamics, a comparison for different farm types shows differences in annual balance between selling and buying of maize (Table 4, details in Annex 3). The additional gain for farm households using metal silos for grain storage ranges from 30 US$ (type A) to 90 US$ (type C), on average 52 US$ or +23%. This calculation is based on conservative assumptions, i.e. selling of own maize production without considering additional buying and selling of maize or added value of maize created by pig rearing etc. (see endnote 5). This additional gain is about 2-6% of the annual earnings of rural households which is in the range of 1460 US$ (Honduras) to 2120 US$ (El Salvador) (rural wages 2007, 1.7 earners per household; Baumeister, 2010). Another comparison can be made with the Gross National Income (GNI/capita) ranging from 1000 US$ (Nicaragua) to 3770 for El Salvador (WDI 2009, World Bank). Compared to these figures, the additional cash income generated by the use of metal silos seems small and is unlikely to be a main driver for silo adoption, especially in the case of subsistence farmers.

Table 4. Annual balance of selling and buying maize according to farm type (model calculations based on survey results)

Farm type (proportion in %)	**Level of maize production (t/farm)**	**Maize stored (%)**[1]			**Stored maize sold (%)**[2]	**Annual balance selling and buying of maize per farm (US$)**[3]		
		Metal Silo	**Other**	**Total**		**Silo user**	**Non-user**	**Difference (= gain silo)**
A (30%)	0.9	90	5	95	5	28	-3	30
B (50%)	1.8	60	20	80	35	281	231	50
C (20%)	2.7	60	10	70	60	635	545	90
Total	1.7	65	15	80	30	276	224	52

[1] Annex 1, Table A1.10; [2] Annex 1, Table A1.11; [3] Annex 3.

3.3.4 Investments



In general, farm households using metal silo for grain storage are more likely to make investments in household items, housing or farm (equipment, infrastructure, animals, land; Annex 1, Table A1.14). Almost 50% of the silo users reported to have made investments during the last 5 years. The average annual amounts invested varies for the different farm types (A<B<C) and is in the range of 37 to 86 US$ and 19 to 63 US$ for silo users and non-users respectively (Figure 4). Differences between users and non-users are significant for farm type A and B only (Annex 1, Table A1.15). Differences between countries are small. These investment figures seem low but are comparable to the calculated additional gain (Table 4) or the cost of a metal silo (average price for 18 qq. silo ranging from 50-60 US$ in the 1990's to 90 US$ in 2009).

Figure 4. Annual investments according to farm type (average 2005-2009)

3.3.5 Cost-benefit analysis of silo

A comprehensive cost-benefit analysis (CBA) of the metal silo was not possible within the scope of this study. However, an approximate CBA based on three contributing factors to the additional benefit of the metal silo as mentioned in the previous chapter (i.e. avoided loss of grain, better selling prices of grain stored in metal silo, less need to buy grain during high price season) is presented. It shows Benefit-Cost-Ratios (BCR) of 2.3 to 3.5 and of 1.3 to 1.9 with and without considering additional institutional costs for the transfer of the metal silo, respectively (Table 5, details of CBA in Annex 4). Internal Rate of Return (IRR) ranges from 47% to 95% and from 18% to 35% with and without considering additional institutional costs for the transfer of the metal silo, respectively. Assuming that an individual farmer would require a BCR of at least 2 to have a guarantee to recover his initial investment in a silo (Kimenju & Groote, 2010), the silo technology looks attractive to farmers. Furthermore, the risk of loosing the entire investment is minimal (hardware technology easy to safeguard and maintain). The BCR and IRR are higher than those reported by Joy (1983) or Coulter et al. (1995) mainly due to higher recent grain prices. Assuming that these prices are likely to remain high in the future, the use of the metal silo will remain attractive. Other studies confirm that the use of the metal silo is attractive to farmers even when the costs of the silos is higher e.g. in Eastern Africa (Tefera, et al., 2010). Nevertheless, the question why not more farmers are acquiring metal silos seems justified. The initial investment required for a silo was often (68%) mentioned by non-adopters as a hindering factor. However, the attitude to wait until a silo "for free " (or subsidized) is obtained through an NGO or government programme (ref. El Salvador, Guatemala) is likely to be another contributing factor for slower adoption.

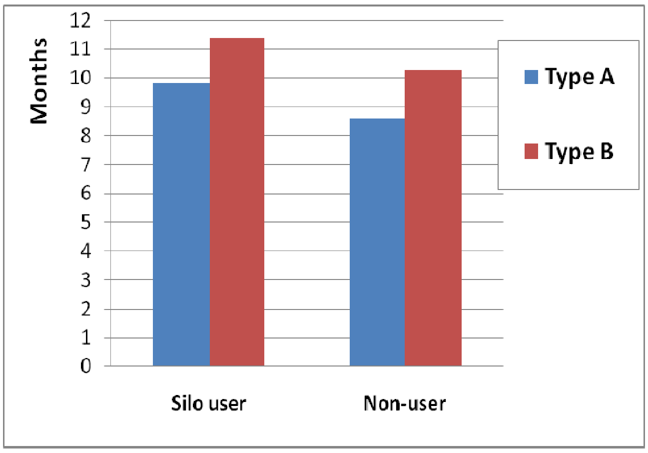
Table 5. Cost-Benefit Analysis of metal silo

Scenario[1] (additional benefit)	Without transfer cost		With transfer cost	
	BCR	IRR	BCR	IRR
Low	2.3	47%	1.3	18%
Medium	2.6	55%	1.4	22%
High	3.5	95%	1.9	35%

[1] details of scenarios and calculations in Annex 4

3.3.6 Food security

All interviewed farms produce maize and the majority use their own production to cover food consumption needs. The households indicated to have an annual food need of 600-800 kg of maize and 100-300 kg of beans (5-6 members/family) which coincides findings from Baumeister (2010). In the case of maize, this quantity corresponds to the storage capacity of the two most commonly encountered silo sizes (12 and 18 quintals).



The number of months households can cover their annual maize consumption needs from stored maize production was taken as a main indicator for food security[7]. In all four countries users of metal silos consistently showed a higher number of coverage compared to non-silo users (Figure 5, details in Annex 1, Table A1.16). Subsistence farmers (type A) showed a lower coverage compared to farm type B.

Figure 5. Coverage of maize consumption by stored maize (year 2009, average of all 4 countries)

Results for thee years (2009, 2008, 2004) show a consistent higher coverage for silo users (type A and B) in the range of 1.0-1.2 months[8]. Thus, it can be argued that the use of metal silo increases food security by approximately 30-35 days per year. This period also corresponds to the estimated average annual quantity of grain saved from loss (approximately 90 kg per household; Annex 2, Table A2.2).

These findings are underpinned by the analysis of the control question of "how many months households need to buy maize and beans". Regression analysis shows that metal silo users in all of the four countries need to buy maize from the market in fewer months (Annex 1, Table A1.17). Country effects show that households in el Salvador need to buy (on average) less maize and beans (also for Nicaragua) than in Guatemala.

Above results confirm findings from other studies. In Honduras, Hannes (1991) reports that 20% of metal silo users and 83% of non-silo users indicated to have a deficit in stored grains (maize, beans) to cover food needs till next harvest. This is confirmed by Gladstone et al. (2002) reporting that 60% of silo users still had some maize stored in the silo before the new harvest, compared to 29% of non-users having still some stored maize.

However, for the interpretation of the relationship between metal-silo use and food security, it is important to consider that silo users are usually characterized by a higher degree of maize self sufficiency. Thus, silo users have either increased their maize production or have already relied on less buying of maize before they had the silo[9]. Therefore, the impact of the metal silo in terms of food security is a combined effect of the metal silo and the higher production level of farms using the silo. Another factor often mentioned by farmer to have contributed to increased food security is off-farm employment (Annex 1, Table A1.20).

3.3.7 Livelihoods and most significant change

To assess the impact of silos on livelihoods, farmers were asked how their situation changed in the last 5 years (2009 vs. 2004) with regard to the nine aspects (livelihood indicators, see Annex 1, Table A1.18). To test the hypotheses that silo users faced a better economic and social development regression analysis was carried out for five indicators i.e. the family's food situation, the family's income situation, the workload of women's, children's health situation, and the children's education situation.

In general, a higher percentage of silo users (and especially farm type A) indicated improvements for all livelihood indicators (Annex 1, Table A1.18). The aspect most frequently mentioned was improved food security. Cross tables for the five indicators (i.e. on development of the family's food situation, the family's income situation, the workload of women's, children's health situation, and the children's education situation) show significant differences between metal silo users and non-users (not shown). For all indicators, farmers from Guatemala indicated the best situation (Annex 1, Table A1.19). More importantly, silo users indicated a significantly better situation compared to non-users. Thus, metal silo user assessed the development of economic and social aspects more positively. However, as in the case for food security, increased off-farm employment was often mentioned as another factor for improvements (e.g. 36% of silo users type A indicated increased off-farm employment as a reason for better income; Annex 1, Table A1.20).

Almost half (44%) of the farmers perceive the reduction of postharvest grain losses as *the most significant change* due to the introduction of the metal silo followed by better health due to clean/high quality grain (17%) and more available grain for consumption (16%) (Annex 1, Table A1.21).

On average, 15% of silo user households mentioned a reduction of the workload for women after the introduction of the metal silo and 5% of the households mentioned reduced workload as the *most important change*. Due to the need for shelling, removing the kernels from the spindle and drying all the grain at once for filling the silo, men are more actively engaged in these operations thereby reducing the workload of women. In addition, the removal of grain from the silo for daily consumption, mainly done by women is more convenient compared to the traditional way of daily shelling and removal of kernels[10].

3.4 Impact of silo production on tinsmiths

3.4.1 Production of silos and clients

The strategy of Postcosecha programme implies a decentralized silo production mainly by artisan tinsmiths. Since the start of the programme, over 2000 tinsmiths have been trained in silo production[11]. The total number of active tinsmiths is difficult to determine since many of them have abandoned the business due to various reasons (migration, no or different business opportunities, no succession etc.) while others have handed it over to their sons or other relatives. However, based on the total number of silos transferred, an estimation of 800-900 active tinsmiths seems accurate[12]. Small and medium tinsmith enterprises (see classification of types according size in Table 6) prevail in Guatemala and El Salvador while micro and small enterprises dominate in Honduras and Nicaragua. Guatemala (91%) and El Salvador (70%) has the highest percentage of tinsmiths organized in tinsmith associations or cooperatives. In these two counties a „concentration process“ seems to be a occurring mainly as a result of government programmes which can be accessed easier by larger and legally registered enterprises or associations than by individual artisan tinsmiths. This is confirmed by the increase of the government as client of tinsmiths (Annex 1, Table A1.22). A special case is El Salvador where larger quantities of silos are produced for government programmes by a few highly productive tinsmiths at military bases[13].

Compared to 2004, the average silo production per tinsmiths has increased by 17% in 2009 (Annex 1, Table A1.23) with unequal trends in the four countries: In Guatemala and Honduras the productivity has been maintained while it has decreased in Nicaragua. In El Salvador, the sharp increase (from average 100 to 300 silos/tinsmith) is a result of recently launched government programmes for increasing food security.

Prices of silos increased since 2004 by an average of 37% which is a direct effect of the increase of the galvanized metal sheets (+41% for the same 5-year period; Annex 1, Table A1.24). Metal sheeting accounts for 80-90% of the material cost of a silo (Bravo, 2009).

Table 6. Distribution of silo business sizes and annual silo production per type
(Year 2009, n=88)

Type of tinsmiths	Guatemala		El Salvador		Honduras		Nicaragua		Total	
	Distribution	No. silos prod.	Distribution	No. silos prod.	Distribution	No. silos prod.	Distribution	No. silos prod.	Distribution	No. silos prod.
Micro (< 50 silos/y.)	12%	33	20%	27	58%	14	65%	22	36%	20
Small (50-200 silos/y.)	33%	110	25%	140	33%	100	30%	89	31%	108
Medium (200-500 silos/y.)	52%	294	35%	364	9%	339	5%	270	28%	315
Big (>500 silos/y.)	3%	677	20%	663	-	-	-	-	5%	666
Total	100%	212	100%	303	100%	72	100%	76	100%	162

3.4.2 Employment and income

In general, the majority of tinsmith families are also farmers (Percentage of households with agricultural activities: Honduras 77%, Guatemala and Nicaragua 72%, El Salvador 60%). In small businesses (up to 200 silos/year) on average 1-2 family members are involved whereas 2-4 members are involved in bigger businesses (>200 silos/year, Table 7). Women are little involved in the fabrication of silos but substantially in the selling. More than 80% of women in Guatemala and Honduras, 68% in Nicaragua and 20% in Honduras indicated to be actively participating in selling of the metal silos and other tinsmith products.

Annual gross income (or revenue; as an indicator for sales volume) of tinsmiths from selling silos and other related products varies greatly depending on the size of business ranging on average from 2100 US$ up to 60'000 US$ (Annex 1, Table A1.25). On average, about 85% of the gross income is derived from selling of metal silos, the rest from the production and selling of other metal products. Bigger businesses specialize more on the production of silos. The tinsmiths in Guatemala and especially in El Salvador show highest gross incomes. The big differences are explained by the way the different types of tinsmiths are operating. Micro-entrepreneurs being mostly farmer tinsmiths dedicate only a few months (off season agriculture) of the year to silo production. Medium and bigger businesses are more commercially oriented tinsmiths with a much higher productivity[14].

Indicated average annual gross income per person is 8600 US$ ranging from about 6'100 US$ (Honduras) to 11'500 US$ (El Salvador) (Table 7). It increases with the size of the business and is higher for Guatemala and El Salvador compared to Honduras and Nicaragua. Assuming a gross margin of 25% on the revenue, the annual gross profit ranges from 550 US$ (micro-entrepreneur) to 5100 US$ for a bigger enterprise. At country level, the average annual gross profit derived from survey results ranges from 1200 to 2300 US$ per tinsmith which is in line with the calculated average gross profit for the different countries (Annex 2, Table A2.2). Gladstone et al. (2002) showed similar results i.e. average of 1160 US$ gross profit per tinsmiths from sales of silos and side products.

In 2009 only 27% of the micro-entrepreneurs indicated the silo business as their main source of income, followed by 60%, 78% and 100% of the small, medium and big silo businesses, respectively (Annex 1, Table A1.26). The micro-entrepreneurs being mostly farmers still derive their main income from agricultural activities. In the case of Nicaragua the silo production seems to become much less important for these micro-entrepreneurs underpinned by the decrease from 36% in 2004 to 9% in 2009 indicating the silo business as main source of income.

Table 7. Total gross income (in US$) per person from sales of metal silos and other products and number of family members involved in the silo business
(as indicated by tinsmiths; figures for 2009)

	Guatemala		**El Salvador**		**Honduras**		**Nicaragua**		**Total**	
Type of tinsmith	US$	No.	US$	No.	US$	No.	US$	No.	US$	No.
Micro (< 50 silos/year)	1880	1.5	3600	1.3	1870	1.4	2340	1.2	2200	1.4
Small (50 -200 silos/year)	5590	1.7	11270	1.7	9560	2.0	6014	1.5	7820	1.7
Medium (200-500 silos/year)	13000	1.7	12310	2.4	15680	4.0	27600	n.a.	13670	2.0
Big (+500 silos/year)	26570	2.0	18550	3.0	n.a.	n.a.	n.a.	n.a.	20600	2.8
Total	9480	1.7	11540	2.1	6120	1.9	6730		8620	**1.8**

The income (gross profit) of tinsmiths is compared with the annual earnings of rural households (more so for the case of farmer tinsmiths) which is in the range of 1460 US$ (Honduras) to 2120 US$ (El Salvador) per year (rural wages 2007) (Baumeister, 2010). Another comparison can be made with the Gross National Income (GNI/capita) ranging from 1000 US$ (Nicaragua) to 3770 for El Salvador (WDI 2009, World Bank). The comparison shows that the income from silo production is attractive for farmer micro-entrepreneurs (as part-time activity) but far more for commercially oriented businesses (mostly full-time silo production).

3.4.3 Financing and investments

In general, only 38% of the region's tinsmiths have used credit or other financing from the different money-lending institutions. Guatemala is the country with the greatest number of tinsmiths provided with loans (82%), followed by Honduras (25%), Nicaragua (18%) and El Salvador (5%). Generally, tinsmiths consider financing to be an important aspect in silo production but they are reluctant to take loans from micro-financing institutions or banks due to the high interest rates.

Tinsmiths who invested indicated amounts invested in 2009 ranging from 1235 US$ (micro-entrepreneurs) to 3925 US$ (big enterprise) with Guatemala and El Salvador showing the highest (3450 US$/year) investments (not shown). As for type of investments/use of income, 28% of the tinsmiths indicated to have invested in improved housing, followed by education of children (22%) and improvements in the farm (18%) and tinsmiths business (16%), the latter being highest in Guatemala (23%) and lowest in Nicaragua (6%) (Annex 1, Table A1.27). Decisions on investment are mostly taken jointly by women and men (from 59% of the cases in Guatemala and Honduras, up to 78% in El Salvador). There are indications that some tinsmith have further invested in the diversification of the business beyond silo production producing a range of other well selling products[15].

3.4.4 Food security

Tinsmiths families cover their food needs either from own production (especially farmer tinsmiths) or by buying. The numbers of months tinsmiths cover their annual food consumption from income generated by tinsmiths business ranges from 5.1 to 9.5 months consistently increasing with the size of the silo business (Table 8). Micro-entrepreneurs being mostly farmers cover a significant part of their food needs from own production whereas bigger businesses generate enough income to buy food. Tinsmiths from El Salvador showed the highest portion of food bought from income of the silo business.

Table 8. No. of months tinsmiths families cover food needs with income from tinsmiths business

Type of tinsmith	Guatemala	El Salvador	Honduras	Nicaragua	Total	Sig.
Micro (< 50 silos/year)	3.5	8.0	3.9	7.3	5.1	0.187
Small (50 -200 silos/year)	6.5	9.0	5.8	8.3	7.1	0.360
Medium (200-500 silos/year)	6.8	10.0	n.a.	n.a.	8.0	0.002***
Big (+500 silos/year)	12.0	8.7	n.a.	n.a.	9.5	0.444
Total	6.4	9.2	4.5	7.8	6.9	0.001***
Sig.	0.060**	0.722	0.368	0.766	0.017***	

*** / ** Significant differences between means p≤0.05 / 0.10 ANOVA (column and rows). Figures for year 2009.

3.4.5 Livelihoods

The majority of tinsmiths from Guatemala and El Salvador, to a lesser extent from Honduras and least from Nicaragua perceived to have improved their livelihoods during the last 5 years (Annex 1, Table A1.28) mainly in aspects like availability of food (72%), income (69%), social status in the community (64%), education of children (62%) and housing condition (61%). Differences between countries are significant, with improvements being mentioned more frequently in Guatemala and El Salvador compared to Honduras and Nicaragua. Improvements were mentioned more frequently by bigger silo producers (significant for most indicators; Annex 1, Table A1.29). These perceptions are in line with silo productivity, income and food security (Table 6, 7 and 8, respectively) and change in silo productivity during the period of 2004-2009 (Annex 1, Table A1.23). These results are confirmed by Gladstone et al. (2002) who found that 9 of 10 tinsmiths indicated to have improved the situation in regards to food security, access to education of children and family health.

As for the level of livelihood change, the ratings for most indicators show a close to "better situation" in 2009 compared to 2004 (Table 9). Highest ratings were given for increased status in the community, availability of food for the family, income, and education of children. Bigger businesses generally indicated higher improvements. The explications given by tinsmiths for the improvement of the different aspects relate to high extent (50-60% of mention) directly to the production and selling of silo and side products.

Table 9. Changes (situation in 2009 vs. 2004) in livelihoods of tinsmiths according to size of tinsmiths business

Livelihood indicator	Micro (< 50 silos/year)	Small (50 -200 silos/year)	Medium (200-500 silos/year)	Total	Sig.
Availability of food for the family	3.5[1]	4.0	3.9	3.8	0.026***
Health of the children	3.4	3.5	3.8	3.6	0.192
Housing condition	3.5	3.8	3.9	3.7	0.033***
Education of children	3.7	3.8	3.8	3.8	0.847
Family employment	3.2	3.6	3.9	3.5	0.002***
Income	3.6	3.7	4.1	3.8	0.017***
Farm production	3.6	3.7	4.0	3.7	0.111
Work load of women	3.2	3.3	3.4	3.3	0.451
Social status in community	3.8	3.7	4.2	3.9	0.042***
Total	3.5	3.7	3.9	3.7	0.026***

*** / ** Significant differences between means p≤0.05 / 0.10 ANOVA (column and rows).

[1] Rating scale: 1=much worse, 2=worse, 3=the same, 4= better, 5= much better.

3.5 Impact at national and regional scale

3.5.1 General impact at regional level

The overall quantitative impact at national and regional (Central America) scale is characterized by the following key figures (for assumptions used and detailed figures per country refer to Annex 2, Table A2.1 and Table A2.2).

- **670'000 metal silos produced/distributed in the period 1983-2009** of which approximately **600'000 are used for grain storage today** (age of silo ≤ 15 years). This is a conservative estimate since a well maintained silo can last 20 years or more.
- **415'000 staple grain producer households (mostly rural[16]) or 2.4 million people directly benefitting from metal silos; this corresponds to an average coverage of 21% of the total staple grain producer households using the metal silo** (highest in Honduras: 35%). The highest potential to further increase the coverage is seen in Guatemala (currently 17%) where the rural population (mainly small staple grain producers) has almost doubled over the last 20 years (50% of staple grain producers in the four countries live in Guatemala).
- **Steady increase of annual storage capacity reaching 380'000 tons of grain stored in metal silos in 2009 (Figure 6).** This amount corresponds to approximately **13% of total annual maize production** or about **20% of maize production stored in Central America** (highest in Honduras: approx. 30%). This "critical mass" of stored grain in metal silos is likely to have a price stabilizing effect, especially at local scale, at a magnitude of 15-40% (see chapter 3.4.2)
- The **current (2009**) storage capacity results in **38'000 tons grain annually saved from loss equivalent to food for about 50'000 families and worth approximately 12 million US$** (prices 2009). Adding the effect of premium prices for later selling/better quality of grain this amount raises to up to **21 million US$ per year** (415'000 household x additional gain of 50 US$/household; Table 4 and Annex 3).
- **336'000 tons grain saved from loss in total for period 1983-2009 worth 75 million US$ (Figure 6).** Including the premium price effect this amount raises to **90-100 million US$** (compared to a total programme investment of approximately 33 million US$, see endnote 17)**.**

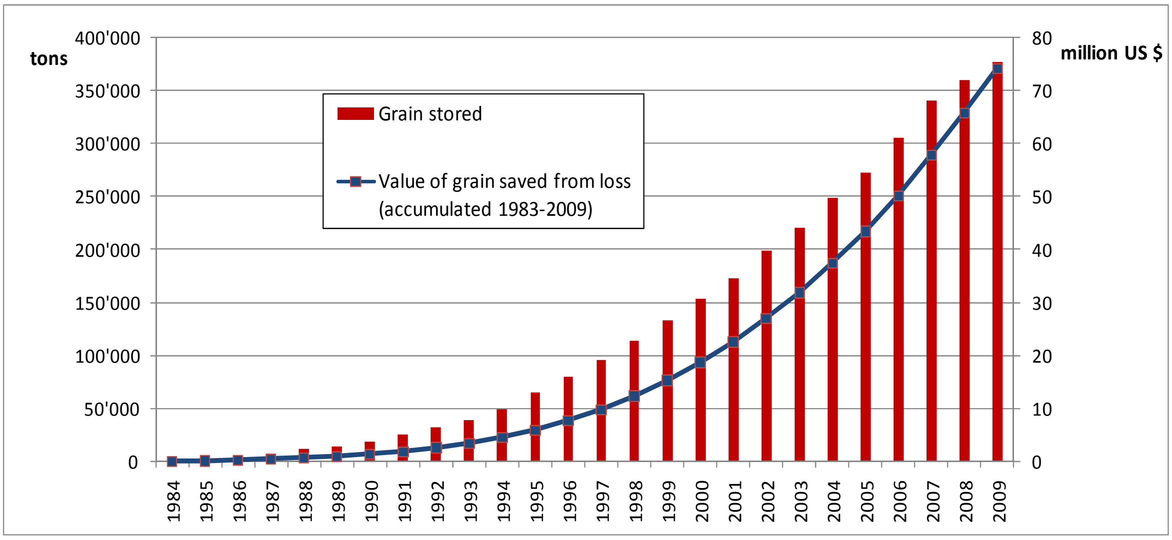


Figure 6. Grain stored in plane metal silos and total value of grain saved from loss (accumulated 1983-2009 for storage capacity; historical prices for maize/beans from FAOSTAT)

Differences between countries can be summarized as follows:

1. The overall quantitative impact of the metal silo is higher in Guatemala and Honduras (70% of all transferred silos are in these two countries) compared to Nicaragua and El Salvador.
2. Honduras has the highest silo density among staple grain producers (35% coverage) but recent silo dissemination dynamics are higher in El Salvador and especially in Guatemala (state programmes), suggesting that the impact will increase more in these two countries.

3.5.2 Effect of maize storage in metal silos on price stability

In terms of price stabilizing effect of the maize storage in metal silos, the following hypothesis is tested: ***The storage of a critical quantity of maize in metal silos reduces inter-seasonal fluctuations at maize prices (farm gate level)***, i.e. less maize is sold after harvest resulting in relatively higher prices during low price period (October till February) and silo stored maize is sold later during periods of scarcity thereby decreasing maize prices during the high price period (May till August (typical intra-seasonal price fluctuations (price index) range from 80-120% in Honduras and from 80-130% in Nicaragua; Annex 5A). In other words: the decentralized maize storage in metal silos and later selling results in a more seasonal balance of offer and demand which has a price stabilizing effect. Due to the inelastic price elasticity of demand, the price effect is disproportional to the demand (Hernandez, 2008).

One basic assumption for such an effect to occur is that markets for (white) maize are autarkic (no imports and exports). In reality, even though Central America can cover most of its white maize consumption by own production (IICA, 2007), the assumption of closed markets does not hold true (e.g. Free Trade Agreements[18]). Therefore, a price stabilizing effect would be diluted i.e. the whole region would be benefitting from it but at lower scale. However, in certain remote areas with little market access (or isolated markets) the effect could be significant (pers. comm. G. Saín). Dutoit et al. (2009) also confirmed that maize price transmission in Latin America seem to be weaker between the international and producer's market than between the international and intermediaries' markets.

A detailed analysis of price fluctuations requires statistical data (time series) for maize farm gate prices at local level which is not available in any of the four countries. Therefore the following approximate analysis is based on several approaches (triangulation):

a) analysis of available time series of wholesale maize prices at regional (departments) and national level (data for Honduras and Nicaragua available only). National farm gate prices were available for Nicaragua only.
b) comparison of statistical price data in 2009 with maize prices indicated by farmers in the survey according to storage method (which is linked to selling time, see chapter 3.3.3, Table 3), and
c) country comparison of maize prices indicated in the survey according to storage (linked to timing of selling) and in relation to silo density (coverage).

a) The comparison of the historic evolution of minimum and maximum wholesale maize prices show a more marked trend of decreasing seasonal price volatility in major maize production zones surveyed in Honduras (Yoro, Intibuca/Lempiras) compared to the capital city Tegucigalpa (Figure 7). In Nicaragua, a decreasing trend for maize price (wholesale) fluctuations is shown for the department of Leon but not for average national farm gate prices and wholesale prices in Managua (Figure 7).

b) Table 10 shows selected statistical maize price data for Honduras and Nicaragua. Average price data from the survey is allocated according to storage methods to minimum, maximum and average of statistical prices considering the link between storage method and timing of maize selling. An interpretation this data is given below.

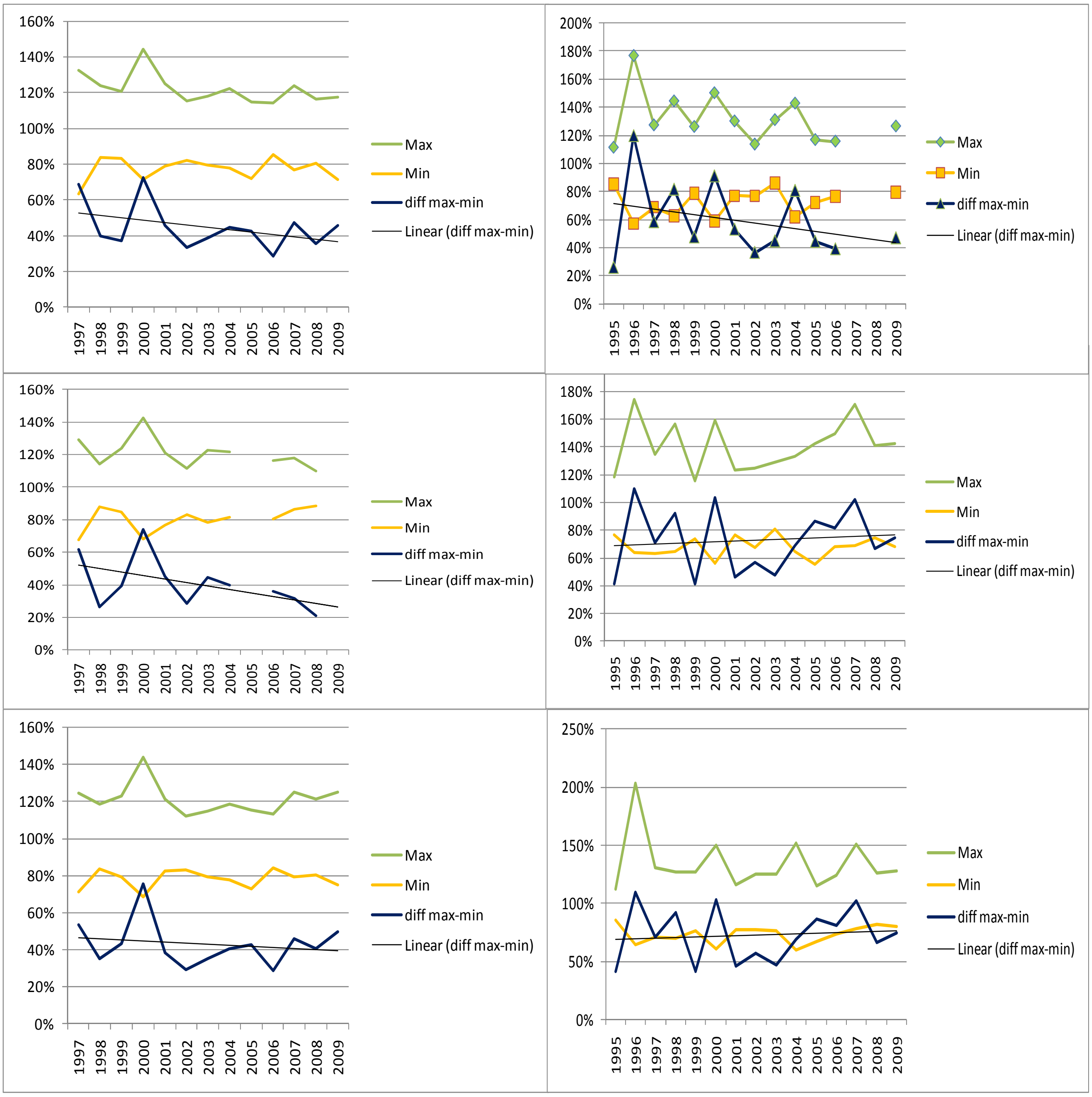


Figure 7: Evolution of maize prices (wholesale) in Honduras and Nicaragua.
(relative maximum, minimum and difference in % of annual average)
Left column from top to down: i) Yoro, ii) Intibucá/Lempiras, iii) Tegucigalpa. Right column from top to down: i) Leon, ii) National average farm gate prices, iii) Managua.

Table 10. Comparison of prices from statistical sources with average prices indicated by farmers according to storage modality

Country	Type of price data (all prices for year 2009 in US$/qq.)	Minimum (% of average)	Maximum (% of average)	Average (=100%)
Honduras	**Wholesale, Tegucigalpa**	**12.3 (75%)**	**20.4 (125%)**	**16.3**
	Survey: sold at harvest	14.3 (93%)		
	Survey: sold metal silo		15.4 (102%)	
	Survey: sold other storage			15.2
Nicaragua	**Farm gate, national average**	**10.8 (68%)**	**22.6 (142%)**	**15.9**
	Survey: sold at harvest	11.1 (89%)		
	Survey: sold metal silo		13.4 (107%)	
	Survey: sold other storage			12.5

Interpretation of Table 10:

Relation of prices from statistical sources with price data indicated by farmers according to storage and selling modality/timing	The following interpretations support a price stabilizing effect
Unstored maize is mainly sold after harvest corresponding to months of lowest prices, i.e. October till February ➔ corresponding to minimum prices.	Prices for maize sold at harvest as indicated by surveyed farmers are higher than minimum prices from statistical sources (especially for Honduras)
Silo stored maize is mainly sold during the months of May till August ➔ corresponding to maximum prices.	Prices for sold maize stored in metal silos as indicated by surveyed farmers are lower than maximum prices from statistical sources.
Maize stored in other systems is sold more distributed throughout the year i.e. November to July, ➔ corresponding more to average prices (i.e. between low/high price levels).	Prices for sold maize stored in other systems as indicated by surveyed farmers are lower than average prices from statistical sources.

c) Finally, a potential price stabilizing effect is thought to increase with the density of silos (coverage). This would be especially the case for Honduras having the highest coverage of silos (35% of staple grain producer households). The differences in maize farm gate prices according to storage method (which is linked to selling time) as indicated in the survey are lowest in Honduras compared to the other countries (Annex 1, Table A1.12) which would confirm this hypothesis.

Conclusions: This analysis gives a fair indication that the critical mass of maize stored in metal silos and sold later contributes to decreasing inter-seasonal price fluctuations. This effect is more likely to occur in Honduras due to the highest silo density among staple grain producer households. A model calculation (Annex 5B) shows a price stabilizing effect of 15-20% (all four countries) and of 30-40% for Honduras, the latter being in line with data shown in Table 10 (case Tegucigalpa vs. survey: relative difference max.-min. prices of 50% and 9% for Tegucigalpa and the survey data, respectively. However, market prices for maize are influenced by many other factors such as government policies, import dynamics, price subsidies, food aid after disasters like hurricanes, earthquakes, global trends like the food price crisis in 2007, price transmission and other specific market forces at sub-regional level (Pérez et al., 2010). A more comprehensive analysis would require more local data and an in-depths analysis which is beyond the scope of this study.

3.5.3 Economic impact of tinsmiths at national and regional scale

The calculated gross profit (margin) generated by tinsmiths from selling silos and side products from remaining metal sheeting is in the range of **12 million US $** during period 1983-2009 (Annex 2, Table A2.2). Corresponding to the number of silos disseminated, the economic benefit is highest in Honduras (34% of total) and Guatemala (37% of total). In addition approximately 3.5 million US $ gross profit for metal sheet traders for the same period (not shown). Furthermore, economic benefits for metal sheet factories, transport business do exist but were not quantified.

4. Validation of Postcosecha intervention model and implication for replication

The Postcosecha intervention model aims at anchoring production and dissemination of the technology in existing institutions and market mechanisms. It includes the following four elements[19]:

1. The metal silo as appropriate and effective technology to protect postharvest loss of grain
2. Decentralized silo production by a network of trained tinsmiths and effective dissemination channels
3. Business model based on public-private development partnership (public funds for technology and strategy development, coordination, training, promotion, quality control and management; private funds for supply of raw materials, installation of tinsmiths workshop, provision of mirco-credit etc.)
4. Existence of an independent management structure within a national institution (e.g. Min. of Agriculture) entrusted with planning, coordination, organization of training, quality control, promotion and controlling.

4.1 Evolution of Postcosecha approach after withdrawal of SDC

The following success factors and limitations were identified in this study (in order of three most important; source: expert interviews):

Main success factors:	Main limitations:
✓ Implementation (production, dissemination, promotion) through inter-institutional alliances (public-private)	❖ Access to material (i.e. galvanized sheets) meeting quality standards
✓ High quality technology accessible to smallholder farmers	❖ High cost of material (i.e. galvanized sheets)
✓ Training of tinsmiths and decentralized silo production	❖ Difficult access to silos (i.e. transport)

Evolution of these factors during the last 6 years (for situation in each of the four countries, see[20]):

- **Inter-institutional alliances** focusing on public and private partnerships: only El Salvador and Guatemala could maintain the dynamic initiated by the programme. In Honduras but especially in Nicaragua, inter-institutional coordination gradually ceased after SDC's support.
- **Quality of technology**: According to experts, quality could be kept at a high level in all countries with the exception of Nicaragua. The role of the coordination unit in quality control is seen as a crucial element in quality control.
- **Access of technology (including cost)**: In El Salvador and Guatemala significant efforts have been made to increase the small farmers' access to the technology. However, the approaches differ from each other i.e. subsidy in Guatemala and donation (in concession) in El Salvador. The latter is seen as more problematic since it is distorting an existing market for silos (direct selling has dropped from 60% in 2004 to 30% in 2009).
- **Training of tinsmith and decentralized production**: With the exception of Nicaragua, training activities (production, entrepreneurship, postharvest storage, etc.) were maintained although not at the same scale as during the support by SDC.
- **Access and high cost of material (input supply chain, i.e. galvanized sheet):** With two factories providing galvanized sheet of the required quality (Guatemala, Costa Rica) the situation has considerably improved. However increased prices (40%) have led to an increased end-user price of the silo which reduces markets.
- **Access to silos** is no longer seen as a major limitation anymore as there is a network of tinsmiths (also ambulant ones producing or assembling silos at the household from pre-fabricated pieces).

In synthesis: There are important differences in the evolution of Postcosecha after the project's end. The experiences give some important insights about the risks and strengths of different setups and their institutionalization. In Nicaragua and Honduras the intervention model could only partially been sustained after SDC's exit due to lack of government commitment. However, a market for silos somehow persisted especially in Honduras. The relative success in Guatemala and more recently in El Salvador can be attributed to a higher level of institutionalization and appropriation by the Government making available own (and channelling donor) resources. The maintenance of experienced key staff of the coordination units who can position postharvest issues with changing governments is another key factor for continuity (ref. examples Guatemala and El Salvador).

4.2 Trends influencing further adoption and up-scaling

Key trends Identified in the interviews which are likely to influence further adoption of silos include:

- ✓ **in favour**: agriculture and food security is re-gaining importance in Central America due to the increased vulnerability of the rural population reflected in recent or upcoming policies (Box 3); new projects based on technology transfer and markets of technologies have been supported during the recent years and many NGOs keep promoting metal silos; metal silos are increasingly seen as a business opportunity (not only by farmers); access to remittances increase the capacity to purchase silos.
- ❖ **against:** increase in price of silo (increased metal price), replacement by cheaper storage technologies (e.g. grain storage bag), increase in drought/climatic variability affecting production and indiscriminate distribution of silos are hindering factors for further adoption of the metal silo.

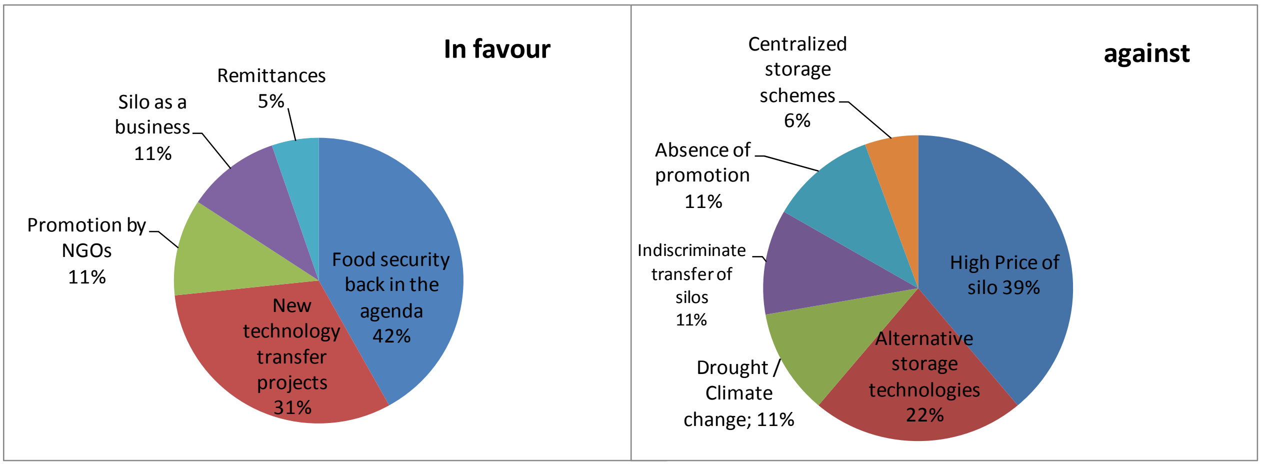


Figure 8. Trends influencing further adoption of metal silos in Central America (source: expert interviews)

BOX 3: Central America – expert views on policies in regards to food security and production of staple grains

In **Nicaragua,** after the restructuration of the State in the 90s, there was a large dispersion of public institutions and the Government stopped financing agricultural production. Currently the yields are stagnating and the production of staple grain has increased mainly due cultivating new lands (agricultural frontier) rather than by increase in productivity. In bad production years, Nicaragua needs to import white maize. Today, there is a better coordination of actions thanks to PRORURAL and a concept of Food Security sovereignty has been created.

In **Honduras,** the main focus has been on middle and large producers. The agriculture on hillsides has only been recognized recently as important for the country. In 1992 The "Ley de modernization agropuecuaria" introduced privatization of services. Nevertheless, the production of staple grains was mainly supported by aid agencies as a result of the dismantlement of state's agricultural extension systems. In Honduras, maize production is remaining at the same (low) level. Periodically, there is a deficit in beans in certain period of the year and the country imports grains from the region. The country has been affected by the recent political turmoil and there is no clear policy or strategy in relation to food security so far.

El Salvador did not have a coherent policy or strategy in relation to food security so far; neoliberal policies disfavored small farmers producing basic grains. Most programmes were biased on giving free inputs to farmers (seeds, fertilizer etc.). Despite the Increase in production through use of improved varieties and inputs the country is still dependent on imports. Currently a consultation process is underway with NGO's, FAO, WFP, farmers associations etc. for the formulation of a Law on Food Security which will include the reduction of postharvest losses. The decentralized storage of basic grains is important as seen in disasters like Mitch and the Earthquake of 2001 where people had access to food from stored grain in intact metal silos. The centralized storage schemes like IRA have failed.

In Guatemala, in general, the public sector has neglected the smallholders. Maize and beans remain the pillars of food security; however, production especially of yellow maize has drastically reduced due to cheap imports from USA. Even though some areas are now planted with bio-fuels (cane, palms), there are still some high potential zones for maize production like in Petén. The problem there is the control of grain humidity (problems of aflatoxins). Today the topic of food security has gained importance (61% of the rural population in Guatemala is under- or malnourished). In addition, there is a lack of an effective mechanism to stabilize prices. Decentralized grain storage by e.g. using metal silos is seen as an ideal approach to increase food security and to contribute to price stabilization..

4.3 Implications for replication

Many attempts to replicate the Postcosecha approach in other countries have been made so far, with different results[21]. Replication approaches include full fledged programme and a leaner setup (i.e. "Postcosecha light" approach) based on pilot actions by interested partners.

From the analysis of expert interviews the following overarching principle can be deducted: the metal silo should not be promoted as a single standing technology for avoiding postharvest loss alone but within a wider strategy of increasing food security, market creation resulting in economic benefits ultimately reducing the vulnerability and poverty of the rural population. Looking at how the silo has been promoted successfully in Central America in recent years, a two-prong promotion strategy becomes evident:

a) **Grain storage as business / improved market integration** (i.e. silo as an element in maize/bean value chains) of small and medium grain producers ➔ non-subsidized silo dissemination as part of a fully commercial activity.
b) **Decentralized grain storage as a strategic element for ensuring food security** especially for the most deprived rural population/subsistence farmers ➔ subsidized silo dissemination is justified as one element of a pro-poor approach (ref. Guatemalan subsidy model).

Contexts differ in each country. Socio-economic and cultural aspects (e.g. food consumption habits) must be studied before starting a replication (1:1 or "blueprint" replication is likely to fail). The following specific elements are deemed important to consider:

1. **Creation of inter-institutional alliances/partnerships (public-private)** with longer-term commitment and clearly defined roles. Market creation is a public task (facilitation); private investments will be made at scale once certain volumes (critical mass) are established (crowding.-in).
2. **Quality product delivered by entrepreneurial tinsmiths:** Training of a critical mass of productive business-oriented tinsmiths, decentralized silo production and rigorous quality control are seen as crucial success factors to be taken over from the Central American experience. The focus on small-scale production of silos by many individual farmer-tinsmiths seems to be less promising / effective due to high costs for training, high transaction costs (e.g. for quality control and monitoring). The lack of economy of scale/market orientation drives many of them out of the business once external programme support ceases.
3. **Targeting/selection of promotion area**: Higher potential areas with sufficient cereal production where postharvest losses are ***perceived*** as an important issue, good capacity of potential clients to acquire silos, and markets (silo being an element in the maize value chain) provide a good environment to demonstrate rapidly the potential of the metal silo to generate (economic) benefits[22]. It implies to concentrate efforts on key cereals in clearly delimited areas reaching a critical coverage. In lower potential areas the metal silo should be promoted mainly as one important element to increase food security along with other measures to ensure sustainable production.
4. **Pricing and affordability**: In line with the two prong strategy, a fully commercial silo market is the base of sustainable production. It can be complemented with a clear pro-poor targeting using "non-distorting" (in fact less distorting) subsidy schemes like successfully applied in Guatemala. Indiscriminate mass distribution of silos (donated) should be avoided but political pressure to do so (especially during elections campaigns etc.) is always a risk.

5. **Innovation and client diversification:** Differentiation of the product according to different demands/social strata of clients could lead to a more diversified offer increasing business opportunities for tinsmiths[23]. In addition, innovative ways to take full benefits of the silo should be explored, e.g. access to micro-credit through warehouse receipt system[24], added value from animal rearing and processing of grain leading to small agribusinesses.
6. **Coordination:** The Central American experience shows clearly that a coordination unit assuming the role of a facilitator (coordination, quality control, networking, organization of trainings, etc.) is necessary. However, such a unit should be inserted ***right from the beginning*** in an existing and ***functional*** structure while maintaining certain operational independence. The unit could gradually disappear if other actors assume its functions. In any case, the unit should abstain from assuming roles of market actors in the value/supply chains[25].
7. **Awareness creation:** Any replication efforts should invest in awareness creation at different levels (farmers, policy makers) of the postharvest loss problem and that there are means to control it effectively. The fact that in many countries in Africa postharvest losses for cereals are even higher compared to Central America (e.g. 16-22% for maize in Eastern Africa[26]) should favour the dissemination of an effective technology to reduce these losses.
8. **Conducive policy framework:** The before-mentioned elements can only converge within an enabling environment provided by conducive policies. This includes aspects like food security through decentralized grain storage, promoting supply chains (e.g. procurement of affordable raw material, taxation/levies), formulation and enforcement of clear subsidy policies, facilitation of access to credit (e.g. for tinsmiths).

5. Conclusions

Production and dissemination of metal silos

The programme Postcosecha has maintained or even increased the dissemination of metal silos after the withdrawal of SDC's support in 2003 (46% of the total of 670'000 silos has been transferred during the period of 2004-2009). An increase of silo dissemination is evident in the case of Guatemala accounting for almost half (44%) of all silos disseminated the same period. For 2010, projections in Guatemala and El Salvador are even higher compared to previous years. ***Overall, this is a sign of successful institutionalization and sustainability of the Postcosecha intervention.***

Outreach and adoption

Approximately 415'000 staple grain producer households have adopted the metal silo for grain storage using on average 1.4 silos. ***The main driver for adoption is the reduction of postharvest grain losses*** in order to increase availability and quality of food for family consumption (especially for subsistence farmers), and to a more limited extent the selling of stored grain (more important for farmers with enough production for selling). Transfer channels and modality of acquisition of the metal silos by households have evolved differently in the four countries: While governmental schemes in Guatemala (subsidies) and more recently in El Salvador (donation in concession) are prevailing, direct selling from tinsmith to farmers paying commercial prices are most important in Nicaragua and especially Honduras. The governmental programmes are likely to affect the market-driven dissemination of silos, especially in El Salvador where farmers refrain from buying if they can expect a "free" silo from governmental programmes. The Guatemalan subsidy approach seems to be less distorting the market since the silo is not given for free and the direct relationship between farmers and tinsmith is mostly maintained.

Impact at household level

Rural households (silo users): The results of the study confirm the positive effects of the metal silo use on rural households in regards to reduction of postharvest grain losses and changes in the use, storage and selling dynamics of grain. Subsistence farmers keep almost the entire production for covering own consumption needs and by using the metal silo they ***have increased their food security by 30 to 35 days per year. Thus, the safely stored grain (mainly maize) in metal silos for later consumption is the most important aspect (savings from less need to buy grain, increased resilience).*** On the other hand, farmers with market access selling some of their produce additionally benefit from the metal silo by selling safely stored grain later during the season when prices are higher. The additional cash income generated in this case is 90US$/year (or 5% of the average cash income per family of 1800 US$) and equals approximately the actual price of a 18 qq. silo. The study confirms that metal silo users who sell grain have a distinct behaviour in regards to timing, selling location and purchaser i.e. more produce is sold later in the season in the village and directly to consumers.

Investments of silo users is in the range of 40-90US$ year and significantly higher than for non-users. The Cost-Benefit ratios of the metal silo ranging from 2.3 (subsistence farmers) to 3.5 (farmers with access to markets) show that the metal silo is becoming more attractive in economic terms for farmers selling maize. However, the lack of initial funds to purchase a silo is still mentioned as a hindering factor for higher adoption.

Finally, the ***metal silo has a significant impact on livelihoods of staple grain producer households with biggest improvements for subsistence farmers especially in Guatemala***. The metal silo users assess the development of socio-economic aspects more positively. Perceived positive changes are foremost related to availability of food, family income, education and health of children, housing condition and workload of women.

However, the metal silo is just one element in a more complex system of the rural household economy and there are many other factors that affect rural households. Technological innovations like the metal silo can only partly offset such macro effects. In particular, increased off-farm employment was frequently mentioned by farmers as contributing factor for improved food security and income. Nevertheless, this study establishes plausible evidence that the adoption of metal silos has improved the ability of individual households to cope with food insecurity and economic stress.

Tinsmiths: An estimated 800-900 tinsmiths are active in the four countries producing silos in a decentralized manner and at different scales. Two third of all tinsmiths are farmers or artisan tinsmiths (1-2 family members engaged in silo production producing typically less than 200 silos per year). Tinsmiths associations are best developed in Guatemala (10 associations). The average annual gross profit per person increases with the size of the silo business ranging from 550 US$ (farmer tinsmith) to 5100 US$ for a bigger enterprise. At country level, the average annual gross profit ranges from 1200 to 2300 US$ per tinsmith being highest in El Salvador. ***These figures show that the production of metal silos is attractive for farmers as an additional off-farm income but far more for more commercially oriented tinsmiths businesses generating a relatively high income*** (compared to GNI). Consequently, most tinsmith families reported ***improved livelihood conditions*** in terms of food security, income and employment, education and health of children, housing condition, and social status within the community. ***These improvements are more frequent for small and medium tinsmith businesses compared to farmer tinsmiths.*** Recent government initiatives in Guatemala and El Salvador for larger-scale dissemination of the metal silos seem to favour bigger tinsmith businesses (individuals or associated). A similar effect is seen in Nicaragua where silo production by farmer-tinsmiths has decreased over the last five years.

Impact at national and regional scale

Aggregated figures of total decentralized ***grain storage capacity reached 380'000 tons/year*** (2009) distributed over 415'000 households or 21% of staple grain producers in the four countries. The ***annual amount of grain saved from loss of 38'000 tons/year worth 12 million US $*** (2009) and the total accumulated (1983-2009) value of grain saved from loss (including the effect of fetching a premium price) of 90-100 million US$ demonstrate the impact of the silo technology at regional (Central America) scale. The volumes stored (estimated to be about 20% of total produced white maize in the four countries) are likely to have a price stabilizing effect in the range of 15-20% for Central America (all for countries) and up to 30-40% in Honduras. ***Overall, the decentralized grain storage in metal silos (especially maize) can be considered of national and regional strategic importance in terms of food security and price stability.***

Appreciation of intervention model (main source: expert interviews)

The intervention model has evolved differently in the four countries since withdrawal of SDC's support in 2003 mainly due to different commitments by the governments i.e. highest in Guatemala and recently also in El Salvador. This appropriation is somewhat unexpected since SDC's presence has been weaker or shorter in these two countries. ***Future trends increasing adoption and contributing to up-scaling are the embedding of the metal silo as one element in national food security strategies and consequently in new projects focussing on technology transfer.*** However, further promotion of the metal silo should not be in detriment of existing silo markets (e.g. through massive donation schemes). The fact that market driven dissemination in Honduras and Nicaragua continues (at a lower level, though) are clear signs in this direction. Hindering factors are high (and fluctuating) metal prices and competition by new storage technologies.

Implications for replication

The Central American experience provides enough insights for successful replication (see points outlined in chapter 4.3). Current trends (i.e. agriculture back on the political agenda, increased political will in many developing countries and donor agencies to address the issue of food security) provide a favourable environment to initiative postharvest initiatives in many other countries. However, postharvest being only one element of food security, it is important to address other limitations in production, marketing and processing of cereals. Without adequate policies and support measures to boost sustainable production farmers may not reach assured production levels (yield stability) which motivates them to acquire metal silos for grain storage. The latest unfavourable climatic developments (increased climatic variability, droughts) in Central America clearly shows the importance to address factors affecting yield stability.

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Further information on Postcosecha Programme: www.postharvest.ch

7. Endnotes

[1] In the case of Honduras this percentage might be overestimated in some particular years. For example DINADERS reported 37'500 silos being distributed (donated) by the government of President Zelaya during the period of 2007-2009.

[2] "El Proyecto Nacional de Maíz Blanco en El Salvador comenzó esta semana la entrega de 350 silos metálicos con capacidad total para almacenar 644 mil libras del grano, a las catorce organizaciones de pequeños productores que participan en este proyecto cofinanciado por Red SICTA, del IICA Cooperación Suiza". Source: Proyecto Red SICTA, Boletín No. 92, 12.4.2010. This shows that SDC is still co-financing indirectly the dissemination of metal silos.

[3] Most farmers using the metal silo also use other (traditional) storage systems which are divers and include: granaries (troja, granero, etc.), barns (tabanco), sacks (plastic, jute); barrels (metal, plastic), cone shaped metal silo (earlier promoted by FAO) etc..

[4] Intra-regional trade is quite important since El Salvador and Costa Rica import substantial amount of maize and beans from Nicaragua and Guatemala.

[5] Other income relevant changes due to the use of metal silo include: increase in production due to better quality seed and investment in inputs, added value by use of grain saved from loss for production of meat (pork, chicken), savings of medical costs due to better health (better nutrition, less intoxication due to use of storage insecticides, savings from decreased need of wood due to substitution of traditional wood-based storage facilities by metal silos, etc. It was beyond this study to quantify these changes. The case of "a metal silo means one pig more" reported e.g. by Gladstone et al. (2002) could not be confirmed in this study may be with the exception of Nicaragua (+0.8 pigs more for silo users).
In the case of savings from a decreased need of wood used for construction of traditional storage facilities (e.g. trojas; Gladstone et al. 2002; Zbinden, 2005) now being replaced by metal silos, the study also did not detect major differences between silo users and non-users. Besides the metal silos, most farmers are replacing the traditional storage techniques by alternatives like metal or plastic barrels, plastic sacks etc. Therefore, savings of wood cannot be attributed mainly to the use of the metal silo and consequently no calculations were made in this respect.

[6] In order to compare the selling location and purchaser of stored and unstored maize, we focus our analysis on metal-silo adopter. This restriction on adopter is necessary to ensure that we compare farms at the same level of consumption and selling patterns. Among the adopters, details of selling of unstored maize are reported from 225 farms, while 123 observations are available for maize stored in metal silos. Details of selling of maize stored in other systems were reported by 89 farms.

[7] Only farm types A and B were considered since type C should by definition (production/consumption >3, see Annex on methods) cover annual food consumption needs.

[8] The No. of months coverage of consumption needs are decreasing from 2004 to 2008 and 2009. However, taking into account inter-annual production fluctuations, one cannot conclude a trend based on 3 year data only.

[9] Annex 1, Table A1.1 shows slightly higher maize and bean production (year 2008) for silo users. The average of all countries shows significant differences in maize production between users and non-users for farm type A and B only.

[10] Gladstone et al. (2002) found that 75% and 78% of households reported that a reduction of the workload for women for operations like shelling and removal of the grain from the cob, respectively. It was noted that the men were helping more in these operations to be done at once and in many case in a semi-mechanized way. The same study also mentions that women report better opportunities to sell maize since the product is ready to sell at any time.

[11] About 70% of tinsmiths (mainly small-scale silo production) are also farmers. According to the impact study conducted in 1995 (Coulter & Bruessel), more than 1100 tinsmiths had been trained by 1994, the majority of them in Honduras where the Programme started in 1983. After the withdrawal of SDC in 2003, the training of tinsmiths declined due to lack of funds. However, the coordination units in Guatemala and El Salvador kept promoting the training of tinsmiths whereas in Honduras the training institute INFOP still offers the training (e.g. through stipends). In Nicaragua, the training has been maintained at a very minimal level. However, the study of Coulter and Bruessel (1995) also revealed that a high percentage (40-80%) of trained tinsmiths did not engage later on in the production of silos. The high percentage of inactive tinsmiths was explained by inadequate selection procedures. In addition, the non-farmer tinsmiths were found to have more capacity to find markets for the commercialization of silos.

[12] The compilation of information by R. Galdámez lists a total of 1110 “active” tinsmith in 2009 (Guatemala 486, El Salvador 190, Honduras 253, Nicaragua 181) indicating that the information is more reliable for El Salvador and Guatemala where the coordination units are still doing some follow-up. However, in the case of Honduras and Nicaragua, the figures are based on old (2003) lists which have limited reliability. The identification of tinsmiths to be surveyed resulted in 10-20% of tinsmiths found inactive. In Nicaragua, 12/22 tinsmith indicated that though they were producing silos in the past they could not sell any in 2009. Thus, adjustments were made accordingly (-30% for El Salvador, Honduras and Nicaragua, and -10% for Guatemala) resulting in an estimated 800-900 active tinsmiths. Considering the total estimated number of silos transferred (310’000 during 6 year period of 2004-2009 = ca. 52’000/year) this results in an annual average silo production of 60 silos per tinsmith, a figure which is close to the average production of silos by individual tinsmiths in Honduras and Nicaragua. In terms of tinsmith associations, Guatemala counts with 10 (9 functioning), Honduras 3 (not known if fully functioning), Nicaragua 2, and El Salvador only 1 functioning. In addition, some family enterprises (famiempresas) emerged in Guatemala (46) and Nicaragua (5). Anecdotic information that the tinsmiths business has spread over generations to more family members and today up to 2500 tinsmiths are producing silos in Central America would result in 150’000 to 250’000 silo disseminated per year (60-100 silos/tinsmiths) which seems unrealistic (and could not be confirmed in this study).

[13] After disasters of hurricane Mitch (1998) and especially the devastating earthquake in 2001 it was observed that most silos remained with grain providing food for many affected people The government of El Salvador seeing the metal silo as an appropriate technology to provide food security after these situations has offered military bases in the country for the production of metal silos. Artisans are provided basic infrastructure and above all a secured working environment. The silos produced are stored within the premises till distributed under the modality of concession by the government during specifically organized events (silo is part of a package with seed, fertilizer etc.). However, in difference with the subsidy model of Guatemala, this scheme is seen more problematic since the direct relationship between farmer and tinsmith (i.e. for proper instruction of farmers how to use the silo) is not assured.

[14] Tinsmiths working under a contract arrangement in military premises in El Salvador produce 3-4 silos of 18 qq. daily. A tinsmith with 4 helpers produces up to 18 silos daily (visit M. Fischler, March 2009). Other studies confirm big differences in productivity of tinsmiths: Coulter and Bruessel (1995) report that non-farmer tinsmiths produced 550 silos per year (average of 13 tinsmiths) while farmer-tinsmiths produced 300 silos per year (average of 26 tinsmiths). Gladstone et al. (2002) report a variation of 62 to 120 silos produced per tinsmiths and year.

[15] There are indications that many tinsmiths with an entrepreneurial spirit have gone much beyond the production of metal silos and minor additional products (using the rest of the metal sheets) only. Examples are the production of chimneys (“estuva Lorena”), water tanks etc. (pers. comm. U. Heierli). It seems that there is an „unfold“ innovation potential which has escaped the Postcosecha Programme focussing on a single (and unchanged) product only. A more diversified product range targeting different clients could have led a more increased development of tinsmiths businesses (reference to Swiss model of cooperative “Landi” offering high quality implements especially but not exclusively to farmers.

[16] Baumeister (2010) indicates a total population of 11.4 million staple grain producers of which 9.7 million or 86% are rural staple grain producers (2007). They account for 62% of the total rural population. The target population of the Postcosecha programme are smaller staple grain producers, most of them are also rural.

[17] Compared to a total investment of about 33 million US $ for the period 1980-2000 (12 million US $ funding SDC, the remainder are contributions by government, NGOs etc; Zbinden, 2005.).

[18] On August 5, 2004, the United States signed the Dominican Republic-Central America-United States Free Trade Agreement (CAFTA-DR) with five Central American countries (Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua) and the Dominican Republic. The CAFTA-DR is the first free trade agreement between the United States and a group of smaller developing economies. This agreement is creating new economic opportunities by eliminating tariffs, opening markets, reducing barriers to services, and promoting transparency. It is facilitating trade and investment among the seven countries and furthering regional integration. The agreement entered into force for the United States and El Salvador, Guatemala, Honduras, and Nicaragua during 2006, for the Dominican Republic on March 1, 2007, and for Costa Rica on January 1, 2009. With the addition of Costa Rica, the CAFTA-DR is in force for all seven countries that signed the agreement. http://www.ustr.gov/trade-agreements/free-trade-agreements/cafta-dr-dominican-republic-central-america-fta

[19] source: http://www.postharvest.ch/en/Home/About_POSTCOSECHA

[20] **Evolution of Postcosecha programme after withdrawal of SDC in 2003:**

a) **El Salvador:** A turning point after the withdrawal of SDC in 2003 was the transfer of the coordination unit from CENTA (Centro Nacional de Tecnologia Agropecuaria) to DGSVA (Dirección General de Sanidad Vegetal y Animal) although physical offices remained at CENTA. DGSVA generates own funds which allowed to keep the unit functional. However, the initial lack of funding commitment by the government for postharvest operations led to a drop in the dissemination of silos (from about 8'000 to 3'000-4'000). Since 2009, the new government is giving more priority to postharvest issues within a national strategy of food security (forecasts for 2010: 25'000-30'000 units). A fully functional coordination unit with experienced staff is maintained thought to be crucial for the continued success of the Programme.
b) **Guatemala:** The continuation of the programme beyond 2003 was most a stake in this country. However, the persistence of the coordination unit and some interventions from SDC at political level led to a gradual positioning of the unit "surviving" many changes of governments and maintaining its experienced staff. Today the unit is directly attached to the ministry of agriculture (MAGA) and is functioning well assuming a role of coordination and quality control. Dissemination figures are impressive and highest of all the four countries (up to 39'000 silos in 2006) which is in line with the highest rural population of the four countries. Larger dissemination schemes funded by EU and other bilateral donors are planned for 2010 (forecast: >60'000 silos). The subsidy model (see Box 1) involving 9 well functioning tinsmiths association is another key success factor.
c) **Honduras:** Having the longest programme history (start 1983), the institutional alliances promoting the programme weakened and finally most of them disappeared. There was no clear commitment of the government to maintain a fully functioning coordination unit and other institutions withdrew (e.g. EAP Zamorano). However the implementation of the postharvest activity was kept going, albeit at low profile by DINADERS (Direccion Nacional de Desarrollo Rural Sostenible) while the training institute INFOP (Instituto de Formacion Profesional) continued offering training for tinsmiths and postharvest storage. However, it is noteworthy that probably due to the longest programme history it is in Honduras where most silos are produced by individual tinsmiths and sold directly to farmers which can be interpreted as a sign of sustainability.
d) **Nicaragua:** After withdrawal of SDC in 2003, the coordination unit of Postcosecha was maintained within INTA (Instituto Nacional de Tecnologia Agropecuaria) but without sufficient funding to be fully operational. The government showed interest in postharvest activities during the election campaign 2003 distributing in 2004 about 20'000 smaller sized (8 qq.) silos. Thereafter, the coordination unit was no hardly operational until recent efforts by new INTA direccion to take back up the postharvest activities. Besides direct selling of silos by tinsmiths to farmers, the dissemination of silos by NGO plays a relatively important role in Nicaragua (survey: 25%).

[21] Many replication efforts of the Postcosecha approach have been undertaken, the most important being: Paraguay, Peru, Cuba, Dominican Republic, Kenya, and in West-Africa. Also a spontaneous spread into Southern Mexico (Chiapas) driven y tinsmiths from Guatemala. Although not at the scale of Central America, these efforts have been relatively sizeable and successful in Cuba and Paraguay (both co-funded by SDC; implemented in Paraguay by Helvetas) and to a more limited extent in Kenya (promotion by Catholic Relief Services – CRS). Other efforts mainly carried out by FAO which has adopted the plane metal silo designed by the Postcosecha programme were undertaken in many other countries (cited in Tefera et al., 2010). Feasibility studies have been undertaken e.g. for Mozambique and Tanzania (Coulter & Schneider, 2004) identifying a big potential for postharvest programmes based on metal silo. The high price of the material (galvanized sheets) as a major problem since the cost of the silo resulted to be double or triple compared to Central America (e.g. about 180 US $ for 900 kg silo).

[22] Replication high potential zones: "While the Postcosecha Programme is technology driven, economic, social and cultural aspects (incl. food consumption habits) are important aspects to consider when postharvest programmes are starting. The programme should focus on zones with high potential for grain production, not going for common donor approach of "poverty alleviation" selecting the poorest pockets of the population. The technology will only partly work in such zones, and limited success will hinder further spreading of the technology". (Keith Andrews, Representative IICA El Salvador, former director of EAP Zamorano, Honduras).

[23] The fact that a product (metal silo) remains almost the same as developed almost 30 years ago is unusual (i.e. one model of silo in different sizes). Opinions differ whether the key to success of the Postcosecha programme is exactly to concentrate on one standard "star product" only or whether the programme could have been even more successful in Central America if it had fostered more innovation in the development and dissemination of metal products. Modifications of the metal silos could include mechanism for faster emptying, smaller and coloured silos for kitchen, bigger square shaped silos for making "silo batteries" (the latter do exist in Nicaragua, pers. comm.. R. Galdámez); besides other metal products etc. (see also endnote 15).

[24] Communal storage, Warehouse Receipt System (WRS): "The metal silo technology would allow an increase in storage capacity at communal level and could also be combined with a WRS allowing smallholders to get access to credit. However, the bottleneck is the lack of established/accepted quality standards which would allow to bulk maize for storage. Currently most farmers want to store their own maize, they are not willing to hand in their harvest and receive back maize from a common store." (S. Urrutia, ex-minister of agriculture, El Salvador).

[25] Referring to the principles of „making markets work for the poor" (M4P) approach.

[26] Average loss estimates 2003-2007 several Eastern African countries range from 14-17% for cereals, and for maize from 16-22% http://www.phlosses.net/index.php?form=losses_estimates.

Annexes:

Annex 1: Additional data tables and figures (results household survey)

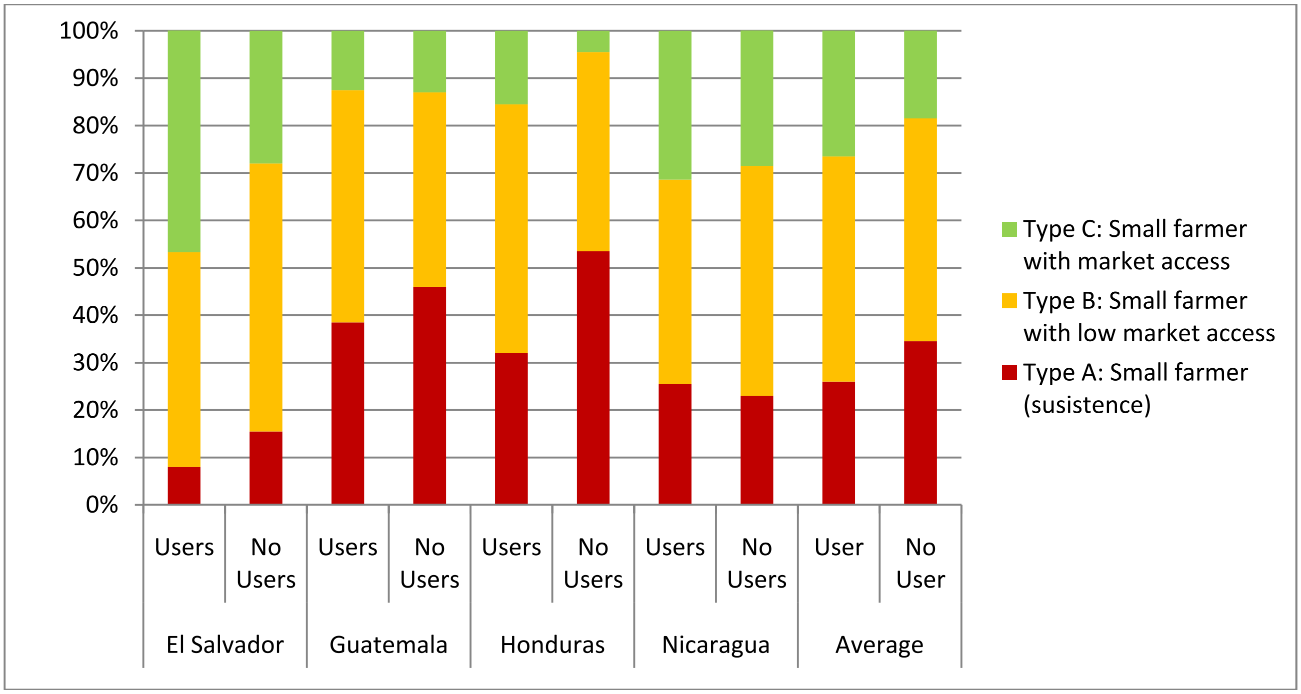


Figure A1.1. Distribution of farm types in household survey (800 users and 800 non-users of metal silos, with equal distribution over 4 countries).

Comments to Figure A1.1:

1. The stratification of producers (type, A, B, C) is based on the ratio of maize production (P) and maize consumption (C) indicated by interviewed farmers, defined as:
   - **Type A: P/C ≤ 1**. Subsistence farmers without market integration.
   - **Type B: P/C >1 and ≤3**. Subsistence farmers with low market integration.
   - **Type C: P >3**. Small to medium farmers with moderate market integration.

   For detailed description see Annex 6.

2. The distribution of farm types selected for the survey show a slight under- and overrepresentation of type A and C, respectively for the silo user group (especially for El Salvador and Honduras). However, overall there are very few significant differences of key characteristics related to production (e.g. farm size) between silo users and non-users <u>of the same type</u> allowing for a direct comparison (Annex 1, Table A1.1). A noteworthy difference, though, is the slightly higher (significant) maize (type A and B) and bean (type B only) production, suggesting that silo users have higher maize self-sufficiency compared to non-users.

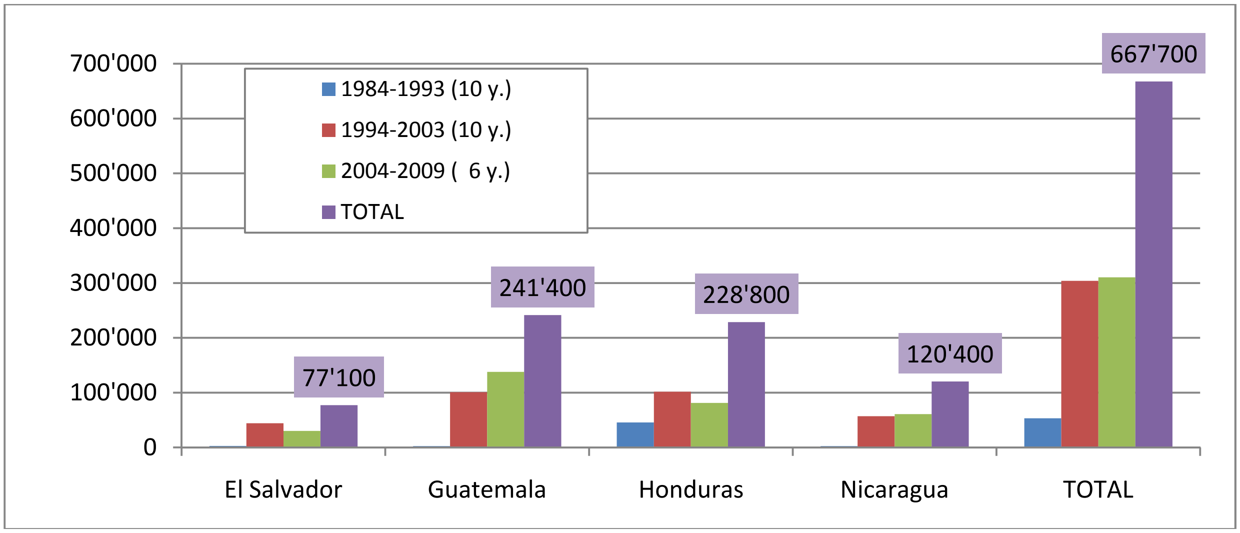


Figure A1.2. Total of metal silos transferred by country and periods.

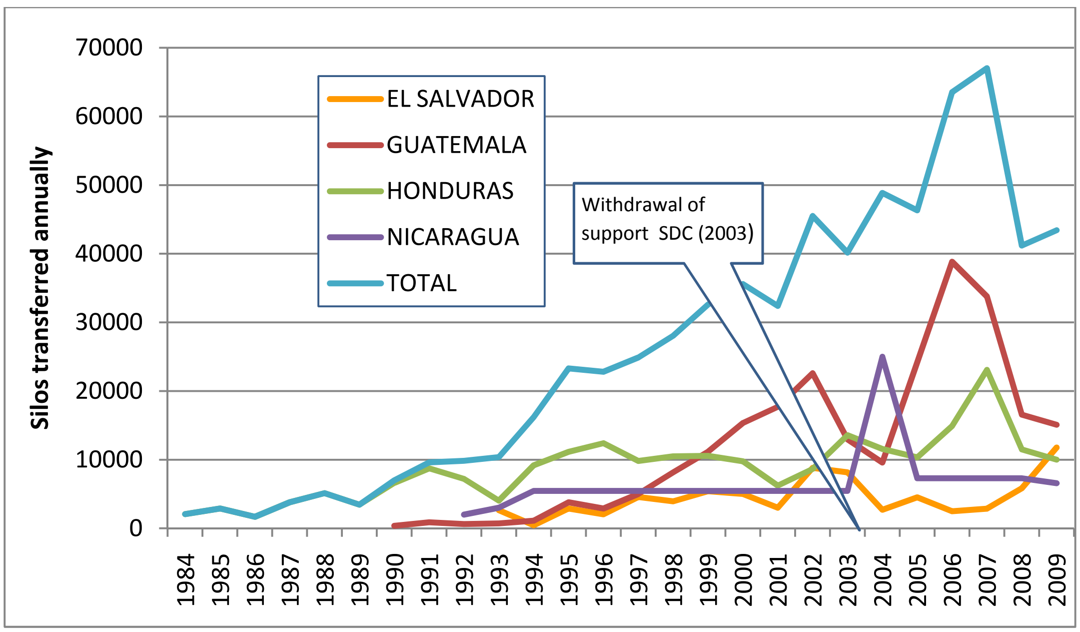


Figure A1.3: Annual transfer of metal silos (per country and total)

Comments to Figure A1.2 and A1.3:

1. Figures are based on data provided by the Postcosecha coordination units (UCPs) of El Salvador and Guatemala, and from INFOP and DINADERS (2007-2009) for Honduras.
2. In the case of Nicaragua, annual silo transfer is based on linear distribution of estimates of total silo transferred. Total estimates are derived from various sources: Reports UCP till 2003, calculations made by R. Galdámez, information provided by INTA, MAGFOR etc.
3. Peaks of silo distributions in a particular year are explained by special silo distribution programmes (e.g. during election campaigns in Nicaragua 2004 government distributed 20’000 smaller sized silos at cost for labour; election campaign 2006 in Guatemala; government Zelaya in Honduras in 2007-2008; new government programme El Salvador in 2009).

Table A1.1: Production characteristics of farm households according to country and type of farmer

Characteristics	Farm type	Guatemala			El Salvador			Honduras			Nicaragua			Total Region		
		Users	Non User	sig.	Users	Non User	sig.	Users	Non Uses	sig.	Users	Non Uses	sig.	Users	Non User	sig.
Total farm size (mz)	A	0.91	0.83	0.522	1.36	1.16	0.398	2.53	2.28	0.520	4.58	4.16	0.546	2.37	2.02	0.169
	B	1.24	1.13	0.390	1.68	1.63	0.737	3.48	2.72	0.116	4.81	4.65	0.783	2.84	2.58	0.265
	C	2.28	2.04	0.740	1.91	1.74	0.644	3.57	4.95	0.539	6.12	6.66	0.512	3.58	4.10	0.280
Total area maize production in 2008 (mz)	A	0.61	0.60	0.870	0.84	0.71	0.269	1.13	1.00	0.26	1.29	0.93	0.034***	0.94	0.82	0.045***
	B	1.09	0.96	0.117	1.16	1.05	0.163	1.58	1.25	0.008***	1.73	1.72	0.96	1.37	1.23	0.010***
	C	1.74	1.44	0.106	1.42	1.11	0.022***	2.03	2.17	0.741	2.44	2.67	0.492	1.82	1.78	0.563
Maize yield in 2008 (qq/mz)	A	23.7	20.9	0.159	25.5	20.1	0.172	15.9	15.6	0.823	6.4	6.5	0.902	17.4	16.5	0.431
	B	30.9	29.8	0.569	26.1	26.0	0.968	19.5	16.9	0.130	16.5	15.00	0.202	23.6	22.2	0.152
	C	35.2	36.6	0.769	33.7	34.8	0.634	21.3	19.9	0.717	29.1	22.7	0.008***	30.9	29.9	0.552
Total maize production in 2008 (qq/mz)	A	12.9	10.6	0.040***	19.9	13.9	0.070**	15.5	13.9	0.365	8.9	6.8	0.148	13.4	11.7	0.052**
	B	29.1	25.7	0.102	28.7	24.6	0.036***	29.2	20.7	0.003***	25.6	23.8	0.385	28.0	23.8	0.000***
	C	59.1	46.9	0.085**	44.3	38.3	0.123	41.3	44.2	0.792	72.6	61.5	0.420	53.2	48.4	0.245
Total area bean production in 2008 (mz)	A	0.11	0.17	0.198	0.25	0.26	0.921	0.39	0.34	0.568	1.04	0.74	0.125	0.42	0.33	0.142
	B	0.36	0.45	0.286	0.78	0.35	0.090**	0.52	0.46	0.500	1.44	1.32	0.471	0.68	0.62	0.335
	C	0.71	0.46	0.185	0.58	0.46	0.260	0.75	1.22	0.126	1.85	1.97	0.748	0.96	1.04	0.575
Bean yield (qq/mz)	A	2.11	2.76	0.471	5.35	2.29	0.069	3.98	3.95	0.976	5.07	4.06	0.384	3.62	3.37	0.658
	B	4.61	4.46	0.882	7.65	5.54	0.033***	6.90	5.18	0.150	9.81	8.61	0.343	7.08	5.92	0.041***
	C	6.21	7.34	0.660	6.02	5.70	0.750	5.68	7.65	0.469	11.7	12.5	0.663	7.51	8.52	0.266
Total bean production in 2008 (qq/mz)	A	0.8	1.5	0.274	4.8	2.0	0.021***	2.5	2.9	0.615	8.4	5.4	0.236	3.3	2.7	0.334
	B	3.1	3.3	0.774	5.3	4.0	0.053**	5.2	3.8	0.150	16.6	14.3	0.353	6.9	6.2	0.236
	C	7.8	4.3	0.207	6.0	4.8	0.240	4.9	5.3	0.331	29.1	30.8	0.807	12.2	13.9	0.502
No. of cattle in 2009	A	1.0	0.6	0.117	0.4	0.6	0.714	1.0	0.3	0.003***	2.2	1.7	0.310	1.2	0.6	0.000***
	B	0.8	0.8	0.997	0.9	0.5	0.103	1.9	0..4	0.000***	1.9	1.5	0.337	1.4	0.8	0.001***
	C	0.9	0.7	0.791	0.8	0.4	0.192	1.4	n.a.	--	3.3	2.5	0.323	1.6	1.1	0.201
No. of pigs in 2009	A	0.5	0.4	0.794	0.2	0.1	0.668	0.1	0.1	0.290	1.0	0.7	0.298	0.5	0.3	0.109
	B	0.2	0.5	0.070**	0.2	0.1	0.514	0.3	0.3	0.602	1.6	0.9	0.067**	0.5	0.4	0.289
	C	0.2	0.4	0.335	0.2	0.1	0.031***	1.2	0.1.	0.417	2.0	1.1	0.122	0.8	0.5	0.140

*** / **Significant differences between means at $p \leq 0.05$ / 0.10 (ANOVA)

Table A1.2: Socio-economic indicators of farm households

Indicator	Guatemala		El Salvador		Honduras		Nicaragua		Region	
	User	Non-user	User	Non-user	User	Non-user	User	Non-user	User	Non-user
Average size of family	5.2	5.2	5.2	4.9	5.7	5.2	5.5	5.3	5.4	5.1
Age head of household	49	43	48	45	49	44	48	47	48	45
Years attended school by head of household	5.8	5.7	3.8	3.6	5.9	5.1	5.7	5.7	5.4	5.0
% female heads households	7.0	11.1	13.9	17.0	12.6	10.2	13.7	11.0	11.7	12.4
% with access to drinking water	71.5	57.3	82.1	76.5	72.3	69.0	54.9	53.5	70.7	64.5
% with electricity	98.5	92.5	88.6	83.0	12.6	8.6	67.4	55.2	67.4	60.2
% with bicycles	41.5	40.2	45.3	39.0	45.5	39.6	48.6	43.6	45.1	40.5
% with motorcycle	5.5	6.0	2.0	0.5	5.2	7.1	6.3	2.3	4.7	4.0
% with TV	74.5	69.3	77.6	59.0	39.3	28.9	60.6	52.9	63.4	52.6
% with mobile phones	75.0	77.4	80.1	72.5	75.9	64.0	55.4	44.2	72.1	65.2

Table A1.3: Distribution of silos according to countries and periods (total and %)

Country	Start of Programme[1]	1984-1993 (10 years)	1994-2003 (10 years)	2004-2009 (6 years)	Total 1984-2009	in % of total for 1984-2009	in % of total for 2004-2009
Honduras	1983	45'625	101'802	81'381	228'800	34	26
Guatemala	1990	2'597	100'777	137'994	241'400	36	44
Nicaragua	1992	2500	57'118	60'785	120'400	18	20
El Salvador	1994	2'628	44'292	30'188	77'100	12	10
Total		50'850	306'489	310'348	667'700	100	100

[1] Refers to official start of the Programme with support from SDC. Some pilot activities producing a small number silos have occurred beforehand. Official support by SDC ended in December 2003.Total rounded to '00.

Table A1.4: Period of acquisition (% of farmers) of metal silo according to country and farm type (A, B, C)

Period of acquisition	Guatemala				El Salvador				Honduras				Nicaragua				Total region
	A	B	C	Total	A	B	C	Total	A	B	C	Total	A	B	C	Total	
More than 10 years ago (before 2000)	3	2	12	4	25	12	11	12	30	36	45	35	31	17	15	20	18
Between 5 and 10 years ago (2000-2004)	35	28	20	30	19	47	39	41	38	43	24	38	42	47	57	49	39
Less than 5 years ago (2005-2009)	62	70	68	67	56	41	50	46	33	21	31	27	27	36	28	31	43
Total	100% (all columns)																

Table A1.5: Number of silos per household according to farm types and country.

Type	Guatemala	El Salvador	Honduras	Nicaragua	Mean	Sig.
A	1.2	1.4	1.1	1.4	1.2	0.003***
B	1.5	1.4	1.3	1.5	1.4	0.057**
C	2.2	1.5	1.7	1.9	1.7	0.005***
Mean	1.5	1.4	1.3	1.6	1.4	
Sig.	0.000***	0.833ns	0.000***	0.022***		

***and ** : Significant differences between means $p \leq 0.05$ and $p \leq 0.10$, respectively, for rows and columns).

Table A1.6: Distribution of silo size per country (%)

Silo size	Guatemala	El Salvador	Honduras	Nicaragua	Mean
4/8 qq (180/360 kg)*	3	7	4	23	8
12 qq (545 kg)	78	17	14	27	41
18 qq (820 kg)	16	69	70	41	43
30 qq (1365 kg)	2	3	11	5	5
Other	1	4	1	4	3
Total	100	100	100	100	100

*1 qq = 45.45 kg

Table A1.7: Capacity of farm families for filling the metal silo (in % of answers) according to country and farm type

Filling of metal silo (during the last 5 years)	Guatemala				El Salvador				Honduras				Nicaragua				Region
	A	B	C	Total	A	B	C	Total	A	B	C	Total	A	B	C	Total	
Always	42	73	68	61	56	47	59	53	61	83	68	74	34	46	68	51	60
Almost always	19	24	27	23	19	40	29	33	23	13	25	18	41	33	26	32	27
Rarely	22	2	5	10	6	4	1	3	12	3	0	6	22	14	6	13	8
Never	17	0	0	7	19	9	12	11	4	0	7	2	3	6	0	4	6
Total	100% (all colums)																

Table A1.8: Advantages of use of metal silo (in % of answers) according to country and farm type

Advantages of metal silo use	Guatemala				El Salvador				Honduras				Nicaragua				Total region
	A	B	C	Total	A	B	C	Total	A	B	C	Total	A	B	C	Total	
Reduction of postharvest grain losses	72	70	64	70	88	91	87	89	59	58	72	61	67	82	67	73	73
Higher availability of grain for family consumption	9	9	16	10	0	3	7	5	23	9	7	14	9	5	20	11	10
Easier management compared to other storage systems	17	9	16	13	0	1	2	2	5	10	7	8	2	3	2	2	6
Better hygiene, easier to keep house clean	1	2	4	2	6	1	0	1	8	14	0	10	11	7	6	7	5
Higher price of grain (maize) at time of selling	0	5	0	2	0	2	1	2	2	5	79	4	0	3	4	3	3
Less exposure to pesticides etc...	1	5	0	3	6	1	2	2	3	3	7	4	9	1	2	3	3
Total	100% (all columns)																

Table A1.9: Reported postharvest losses according to country and storage system

Country	Metal silo		Other storage systems	
	% of silo users who reported losses	% estimated maize losses	% of users and non-users who reported losses (*)	% estimated maize losses
Guatemala	1	7.5	38.5	10.7
El Salvador	8.5	5	56.4	10.2
Honduras	4	2.7	24.7	8.7
Nicaragua	11.3	2	53.3	8.9
Total	6.2	4.3	43.2	9.7

(*): Calculated based on all producers, silo users (72%) and non-users who have other storage systems (100%).

Additional note:

- Only 10 farmers (<1%) reported losses equal or higher than 10% up to a max of 20% for grain stored in metal silos.
- 317 farmers (21%) of farmers reported losses of 10% or higher for grain stored in other storage systems (a combination of traditional storage methods such as trojas, barrels, sacks etc.)

Table A1.10: Use of maize production according to country and type (in %)

Farm type	Use of maize production	Guatemala		El Salvador		Honduras		Nicaragua		Region	
		User	Non-user	User	Non-user	User	Non-user	User	Non-user	User	Non-user
A	Sold/used right at harvest	2	1	3	8	13	12	14	13	8	8
	Stored in metal silo	82	-	96	--	78	--	62	--	78	--
	Stored in other storage systems	15	99	2	92	9	88	24	87	14	92
	Total	100% (all columns)									
B	Sold/used right at harvest	15	7	21	24	22	21	21	27	20	20
	Stored in metal silo	62	--	60	--	64	--	53	--	61	--
	Stored in other storage systems	23	93	20	76	14	79	26	73	20	80
	Total	100%									
C	Sold/used right at harvest	41	23	36	39	32	50	35	42	36	38
	Stored in metal silo	39	--	47	--	52	--	38	--	42	--
	Stored in other storage systems	20	77	18	62	16	50	28	58	22	62
	Total	100% (all columns)									
Total	Sold/used right at harvest	21	10	28	28	23	20	32	35	27	25
	Stored in metal silo	58	--	54	--	64	--	40	--	53	--
	Stored in other storage systems	21	90	18	72	14	80	28	65	21	75
	Total	100% (all columns)									

Table A1.11: Use grain stored in metal silo

Farm type	Use of grain stored in metal silo	Guatemala	El Salvador	Honduras	Nicaragua	Region
A	Consumption	95	96	92	93	94
	Seed	3	<1	5	5	4
	Sale	2	4	3	2	2
	Total					100%
B	Consumption	74	65	79	77	74
	Seed	3	1	5	5	4
	Sale	23	34	16	18	23
	Total					100%
C	Consumption	52	41	60	59	51
	Seed	1	<1	4	3	2
	Sale	47	59	35	38	47
	Total					100%
Total	Consumption	74	55	79	71	70
	Seed	3	<1	5	4	3
	Sale	23	44	16	24	27
	Total					100% (all columns)

Table A1.12: Average prices (US$/quintal) received for maize and beans in 2009 according to sale

Grain type and sale modality	Guatemala	El Salvador	Honduras	Nicaragua	Average	Sig.
Maize						
Sold at harvest	13.8	11.8	14.4	11.1	12.5	0.000***
Stored in metal silo	16.0	14.1	15.4	13.4	14.6	0.000***
Other storage system	14.6	13.9	15.2	12.5	13.8	0.000***
Difference in price when sold at harvest and when stored in silo	2.2 (0.000)***	2.3(0.000)***	0.9 (0.369) ns	2.3 (0.000)***		
Beans						
Sold at harvest	42.2	36.3	26.1	24.3	29.2	0.000***
Stored in metal silo	43.8	37.8	28.9	24.6	31.3	0.000***
Other storage system	47.8	38.7	26.0	24.9	34.8	0.000***
Difference in price when sold at harvest and when stored in silo	1.6	1.5 (0.469)ns	2.8 (0.041)***	0.3 (0.820)*		

**Significant difference between the means at the 0.05 level of significance. ANOVA statistical test (rows)

***Significant difference between the means at the 0.05 level of bilateral significance

Table A1.13: Regression analysis: Maize price for different storage systems (n=1195; i.e. only type A+B)

	Maize Price in US$/qq.
Intercept	13.70 (43.44)***
Dummy Storage Metal Silo (vs. Unstored)	1.85 (5.07)***
Dummy Other Storage System (vs. Unstored)	1.46 (5.14)***
Dummy El Salvador	-1.38 (-4.27)***
Dummy Honduras	0.54 (1.39)
Dummy Nicaragua	-2.75 (-7.37)***
Degrees of Freedom	837
Adjusted R2	0.14

Table A1.14: Farm households making investments during the last 5 years (2004-2009; in % of answers)

Farm type	Guatemala			El Salvador			Honduras			Nicaragua			Región		
	Users	Non Users	sig.	Users	Non Users	sig.	Users	Non Users	sig.	Users	Non Users	sig.	Users	Non Users	sig.
A	44	31	0.069**	25	20	0.703	57	28	0.000***	40	45	0.621	46	31	0.001***
B	34	39	0.439	37	16	0.000***	55	39	0.029***	58	39	0.010***	46	32	0.000***
C	50	52	0.901	31	33	0.847	52	67	0.437	71	57	0.123	49	48	0.771

Table A1.15: Annual amounts invested (household items, housing, farming equipment and land) according to country and farm type. Average over last 5 years (2004-2009) in US $.

Farm type	Guatemala			El Salvador			Honduras			Nicaragua			Region		
	Users	Non Users	sig.	Users	Non Users	sig.	Users	Non Users	sig.	Users	Non Users	sig.	Users	Non Users	sig.
A	36	18	0.075**	8	13	0.605	60	23	0.001***	21	16	0.519	37	19	0.001***
B	47	45	0.882	50	12	0.005***	61	34	0.081**	62	32	0.050***	55	29	0.001***
C	106	67	0.458	72	60	0.735	62	63	0.979	114	64	0.140	86	63	0.258

Table A1.16: Satisfaction of annual household maize consumption needs from stored maize (in No. of months/year; type A and B only[1])

Country	Farm type	No. of months covering consumption needs in 2009			No. of months covering consumption needs in 2008			No. of months covering consumption needs in 2004		
		Users	Non Users	sig.	Users	Non Users	sig.	Users	Non Users	sig.
Guatemala	A	9.2	8.1	0.012***	9.7	8.4	0.004***	10.1	8.7	0.001***
	B	10.9	10.3	0.039***	11.5	10.7	0.001***	11.6	10.5	0.001***
El Salvador	A	10.9	9.6	0.092**	11.1	10.8	0.595	11.2	10.0	0.081**
	B	11.4	10.4	0.001***	11.4	11.3	0.413	11.5	10.4	0.006***
Honduras	A	9.5	8.2	0.017***	10.1	8.6	0.002***	9.9	8.7	0.024***
	B	11.5	10.3	0.000***	11.4	10.8	0.020***	11.3	10.1	0.003***
Nicaragua	A	9.2	7.7	0.042***	8.6	7.5	0.173	8.7	7.1	0.090**
	B	10.4	9.3	0.036***	10.8	10.4	0.788	11.2	10.1	0.009***
Region	A	9.4	8.3	0.000***	9.7	8.5	0.000***	9.8	8.6	0.000***
	B	11.1	10.1	0.000***	11.3	10.3	0.000***	11.4	10.3	0.000***

[1] By definition, households of type C fully cover their annual consumption needs.

Table A1.17. Regression analysis on the determinants of number of months when additional food buying was necessary (average values for 2008/2009; n=1187 i.e. only farm type A + B).

	Number of months when maize has to be bought	**Number of months when beans has to be bought**
Intercept	1.32***	3.05 ***
Dummy Non-User (vs. User)	0.77 ***	-0.28 n.s.
Dummy El Salvador[1]	-0.59***	-0.91 ***
Dummy Honduras[1]	-0.18 n.s.	-0.44 n.s.
Dummy Nicaragua[1]	0.12 n.s.	-0.95 ***
Dummy Non-User x Dummy El Salvador[1)]	-0.30 n.s.	1.45 ***
Dummy Non-User x Dummy Honduras[1)]	0.07 n.s.	0.46 n.s.
Dummy Non-User x Dummy Nicaragua[1)]	-0.31 n.s.	0.54 n.s.
Degrees of Freedom	1187	1187
Adjusted R2	0.06	0.01

Note: [1)] Country specific effects are evaluated against Guatemala as reference category.

Table A1.18: Farm households mentioning to be in a better situation in 2009 compared to five years ago (in %).

Improved livelihood indicator	Farm type						Total		
	A		B		C				
	Users	Non Users	Users	Non Users	Users	Non Users	User	Non User	Difference user/non-user
1) Food for family/food security	51	25	40	29	38	35	43	28	15
2) Family income	38	22	37	23	36	31	38	25	13
3) Education of the children	38	26	36	31	32	24	36	28	8
4) Housing conditions	38	27	34	25	32	26	35	26	9
5) Health of children	37	26	34	28	30	22	34	26	8
6) Social status in community	33	26	32	22	25	23	31	24	7
7) Farm production	32	16	28	22	21	28	28	22	6
8) Family employment	28	14	22	14	23	17	24	15	9
9) Workload of women	16	7	15	10	10	6	15	8	7
10) Average all indicators	35	21	31	23	28	24	30	23	7
Difference user/non user	14		8		4		7		

Table A1.19: Regression analysis on the assessment of economic and social aspects of family living (situation 2009 compared to five years ago; type A+B only).

	Food Aspects	Family Income	Women's Workload	Children's Health	Children's Education
Intercept	2.27 (41.09)***	2.46 (45.32)***	2.70 (57.63)***	2.41 (49.73)***	2.48 (46.64)***
Dummy Non-User (vs. User)	0.50 (6.35)***	0.41 (5.28)***	0.28 (4.35)***	0.28 (3.99)***	0.18 (2.41)**
Dummy El Salvador[1]	0.46 (5.19)***	0.37 (4.26)***	0.33 (4.72)***	0.26 (3.33)***	0.20 (2.46)**
Dummy Honduras[1]	0.25 (3.19)***	0.18 (2.30)**	0.19 (2.90)***	0.28 (4.07)***	0.11 (1.48) (n.s.)
Dummy Nicaragua[1]	0.78 (9.12)***	0.57 (6.69)***	0.23 (3.35)***	0.57 (7.61)***	0.22 (2.73)***
Dummy Non-User x Dummy El Salvador[1]	-0.42 (-3.46)***	-0.25 (-2.11)(n.s.)	-0.30 (-3.10)***	-0.19 (-1.77)**	0.02 (0.14) (n.s.)
Dummy Non-User x Dummy Honduras[1]	-0.28 (-2.52)**	-0.14 (-1.25)**	-0.17 (-1.86)**	-0.18 (-1.87)**	-0.11 (-1.05)(n.s.)
Dummy Non-User x Dummy Nicaragua[1]	-0.41 (-3.37)***	-0.34 (-2.80)***	-0.26 (-2.78)***	-0.33 (-3.11)***	-0.23 (-2.03)**
Degrees of Freedom	1176	1163	1080	1150	1099
Adjusted R2	0.11	0.07	0.03	0.06	0.02

Note: [1)] Country specific effects are evaluated against Guatemala as reference category. Answer scales range from 1 (high improvement) to 5 (severe worsening), while 3 indicates no changes. Thus, smaller values indicate a better situation. Answers that indicated I don't know are not considered in the regression analysis. Furthermore, missing values are generated if the question did not apply for certain interviewed families (e.g. without children).
For all indicators, farmers from Guatemala indicated the best situation (smallest values; dummies for all other countries are significantly positive)

Table A1.20: Reasons for improvement) in food security and income during the last five years (2009 vs. 2004) as indicated by farmers (% of farmers indicating reasons)

Reason for improvement	Farm type	Better alimentation of family (food security)		Better income	
		Users	Non User	Users	Non User
Reduced loss of grain after harvest	A	26	3	4	5
	B	15	4	6	2
	C	13	0	7	0
Better selling of grain	A	9	8	10	2
	B	23	12	19	11
	C	30	27	30	15
More farm production (staple grains, general)	A	19	22	17	16
	B	26	29	20	16
	C	18	24	25	21
More off-farm employment	A	27	32	36	33
	B	14	19	28	22
	C	14	19	7	20

Table A1.21: The most important change caused by the introduction of the metal silo as indicated by farm households (in %)

Most important change due to use of metal silo	Guatemala				El Salvador				Honduras				Nicaragua				Region			
	A	B	C	Tot	A	B	C	Tot	A	B	C	Tot	A	B	C	Tot	A	B	C	Total
Reduction of postharvest grain loss caused by insects pests and rodents	48	45	16	43	57	63	54	58	30	33	46	33	50	48	26	40	44	47	41	44
Better health/hygiene due to high quality (healthy) grain stored	27	23	36	26	14	9	10	10	13	9	8	10	19	21	19	22	20	16	15	17
More available grain for family consumption	8	9	4	8	<1	6	11	8	48	46	21	42	3	7	15	9	18	17	12	16
Better selling of grain stored (mainly maize)	<1	4	12	4	<1	9	10	9	<1	1	17	4	6	<1	13	6	1	4	12	5
Less work in postharvest handling of grain	9	10	12	10	21	3	5	6	<1	<1	4	1	3	1	2	2	6	4	5	5
Others	8	8	20	10	7	10	11	9	9	11	4	10	19	23	26	22	11	13	15	13
100% (all columns)																				

Tinsmiths

Table A1.22: Changes in clients of tinsmiths during the last 5 years (in %)

Client	Guatemala		El Salvador		Honduras		Nicaragua	
	2009	2004	2009	2004	2009	2004	2009	2004
Individual farmer	12	9	29	61	78	78	33	21
NGO's	15	27	7	28	13	17	50	58
Government	73	61	57	**	**	**	17	16
Others*	-	3	7	11	9	4	-	5
Total	100	100	100	100	100	100	100	100

*Intermediaries, companies, cooperatives, etc.. **most likely not nil, underestimated.

Table A1.23: Changes in silo production per tinsmiths during the last 5 years

Country	All silos					Silos 18 qq				
	2009		2004		dif	2009		2004		dif
	n	No. silos	n	No. silos		n	No. silos	n	No. silos	
Guatemala	33	212	26	243	-13%	27	46	24	71	-36%
El Salvador	20	300	18	106	182%	19	243	18	62	296%
Honduras	23	72	22	60	20%	23	26	20	30	-11%
Nicaragua	12	76	16	110	-30%	10	31	12	63	-50%
Total	88	162	82	138	17%	79	86	74	56	52%
Sig.		.000***		.000***			.000***		.000***	

***Significant differences between means p≤0.05 ANOVA. (column)

Table A1.24: Changes in selling prices, material and labour cost during the last 5 years (in US $)

Item	Guatemala		El Salvador		Honduras		Nicaragua		Total		
	2009	2004	2009	2004	2009	2004	2009	2004	2009	2004	Increase 2009 (%)
Price of silo (18 qq.)	90.4	62.3	89.3	71.4	112.7	86.8	90.9	59.0	95.9	69.9	+37.1
Unit price of metal sheet (Postcosecha, 3x6 feet)	12.1	8.2	11.3	8.5	14.5	12.1	13.7	7.6	12.9	9.1	+41.8
Unit price tin-solder (per pound)	9.3	5.6	12.9	8.1	15.0	8.4	9.1	6.2	11.6	7.1	+63.6
Daily worker salary	11.0	8.4	12.7	9.7	12.1	6.3	6.9	6.6	10.7	7.8	+37.7

Table A1.25: Total gross income (in US$) per tinsmith business from sales of metal silos and other products per business as indicated by tinsmiths (figures for 2009 rounded to '00; % indicates gross income of silo/total)

Type of tinsmith	Guatemala		El Salvador		Honduras		Nicaragua		Total	
	US$	% silo	US$	% silo	US$	% silo	US$	% silo	US$	% silo
Micro (< 50 silos/year)	2500	70	3800	53	2100	71	2800	63	2500	65
Small (50 -200 silos/year)	9000	70	13800	84	13600	80	6900	76	10600	77
Medium (200-500 silos/year)	20500	87	31600	87	30100	82	27600	98	24400	87
Big (+500 silos/year)	53100	81	60700	90	n.a.	--	n.a.	--	59200	89
Mean	**15500**	**83**	**27400**	**86**	**8200**	**81**	**6900**	**81**	**15100**	**85**

Table A1.26. Percentage of tinsmiths indicating the selling of metal silos and side products as main source of income (comparison 2009 and 2004)

Type of tinsmith	Guatemala		El Salvador		Honduras		Nicaragua		Total	
	2009	2004	2009	2004	2009	2004	2009	2004	2009	2004
Micro (< 50 silos/year)	50	25	75	75	21	23	9	36	**27**	**35**
Small (50 -200 silos/year)	36	60	60	75	75	50	83	100	**60**	**71**
Medium (200-500 silos/year)	71	77	100	100	100	100	100	100	**78**	**82**
Big (+500 silos/year)	100	100	100	100	n.a.	n.a.	n.a.	n.a.	**100**	**100**
Total	**58**	**66**	**85**	**90**	**46**	**39**	**30**	**50**		

Table A1.27: Investments of tinsmiths in 2009 (% mentioning, total = 100%)

Type of investment	Guatemala	El Salvador	Honduras	Nicaragua	Total	
Housing	28.8	28.6	41.2	16.7	27.6	0.093**
Education of children	15.0	23.8	14.7	37.0	22.4	0.015***
Farm improvement	17.5	14.3	8.8	25.9	17.6	0.197
Tinsmith business	22.5	16.7	14.7	5.6	15.7	0.070**
Other commercial activity	7.5	7.1	11.8	0.0	6.2	0.129
Other	8.8	9.5	8.8	14.8	10.5	0.692
Total	100	100	100	100	100	

*** / **Significant differences between means p≤0.05 ANOVA

Table A1.28: Percentage of tinsmiths households indicating to be in a better or much better situation compared to five years ago (2009 vs. 2004: in order of decreasing importance of total)[1].

	Guatemala	El Salvador	Honduras	Nicaragua	Total	Sig.
Availability of food for the family	82	85	58	59	72	0.064**
Income	82	90	58	41	68	0.001***
Social status in community	63	80	67	50	64	0.246
Education of children	65	82	67	41	62	0.058**
Housing condition	76	65	58	36	61	0.031***
Farm production	72	78	45	39	61	0.027***
Family employment	63	70	67	27	54	0.013***
Health of the children	75	75	39	27	53	0.000***
Workload of women	50	25	50	0	34	0.000***

*** / **Significant differences between means p≤0.05 / 0.10 ANOVA (rows)

[1] Category >500 silos produced/year was not included.

Table A1.29: Percentage of tinsmiths households indicating to be in a better or much better situation compared to five years ago according to country and type of tinsmiths (2009 vs. 2004)[1].

Country	Type	Availability of food security	Health of children	Housing condition	Education of children	Family employment	Family income	Farm production	Work load of women	Status in community	Total
Guatemala	Micro (< 50 silos/year)	100.0	75.0	75.0	100.0	75.0	100.0	75.0	0.0	25.0	69.4
	Small (50 -200 silos/year)	81.8	72.7	81.8	63.6	30.0	63.6	62.5	63.6	45.5	62.8
	Medium (200-500 silos/year)	76.5	75.0	76.5	56.3	76.5	88.2	76.5	52.9	87.5	74.0
	Total	81.3	74.2	78.1	63.3	61.3	81.3	72.4	50.0	64.5	69.6
	Sig.	0.580	0.991	0.939	0.379	0.047***	0.168	0.781	0.091**	0.014***	
El Salvador	Micro (< 50 silos/year)	75.0	25.0	25.0	33.3	25.0	50.0	100.0	0.0	50.0	42.6
	Small (50 -200 silos/year)	100.0	60.0	60.0	100.0	80.0	100.0	75.0	20.0	80.0	75.0
	Medium (200-500 silos/year)	85.7	100.0	85.7	83.3	71.4	100.0	75.0	28.6	100.0	81.1
	Total	87.5	66.7	62.5	76.9	62.5	87.5	81.8	18.8	81.3	69.5
	Sig.	0.575	0.040***	0.152	0.116	0.224	0.026***	0.706	0.559	0.139	
Honduras	Micro (< 50 silos/year)	57.1	38.5	57.1	72.7	50.0	50.0	45.5	57.1	78.6	56.3
	Small (50 -200 silos/year)	62.5	37.5	62.5	62.5	87.5	62.5	28.6	25.0	50.0	53.2
	Medium (200-500 silos/year)	50.0	50.0	50.0	50.0	100.0	100.0	100.0	100.0	50.0	72.2
	Total	58.3	39.1	58.3	66.7	66.7	58.3	45.0	50.0	66.7	56.6
	Sig.	0.948	0.953	0.948	0.807	0.125	0.423	0.226	0.127	0.375	
Nicaragua	Micro (< 50 silos/year)	38.5	23.1	23.1	38.5	23.1	46.2	27.3	0.0	46.2	29.5
	Small (50 -200 silos/year)	100.0	33.3	66.7	50.0	16.7	16.7	75.0	0.0	33.3	43.5
	Medium (200-500 silos/year)	100.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	100.0	44.4
	Total	60.0	25.0	35.0	40.0	20.0	40.0	43.8	0.0	45.0	34.3
	Sig.	0.023	0.778	0.150	0.667	0.854	0.243	0.147	-	0.502	
Total	**Micro (< 50 silos/year)**	**57.1**	**35.3**	**42.9**	**57.7**	**40.0**	**54.3**	**48.3**	**22.9**	**57.1**	**46.1**
	Small (50 -200 silos/year)	**83.3**	**53.3**	**70.0**	**65.5**	**51.7**	**60.0**	**56.5**	**33.3**	**50.0**	**58.2**
	Medium (200-500 silos/year)	**77.8**	**76.0**	**74.1**	**60.0**	**74.1**	**92.6**	**79.2**	**48.1**	**88.5**	**74.5**
	Total	**71.7**	**52.8**	**60.9**	**60.7**	**53.8**	**68.4**	**60.5**	**33.7**	**63.7**	**58.4**
	Sig.	**0.046***	**0.007***	**0.019***	**0.788**	**0.027***	**0.003***	**0.066***	**0.115**	**0.006***	

*** / **Significant differences between means p≤0.05 / 0.10 ANOVA (columns = type of tinsmiths)

[1] Category >500 silos produced/year was not included.

Annex 2: Key impact figures

Table A2.1. Assumptions and general data for calculation of key impact figures

Assumptions / General data	Unit	Value	Sources/comments
A. Silo users			
Lifespan of silo	years	**15**	Confirmed by experts in validation workshop March 2010, Managua
Fraction of maize of total grain stored	%	**95%**	Beans taken as 5% (acc. to household survey results)
Families using adquired metal silo	%	**95%**	Household survey 2010
Filling capacity of families using silo (adj. for yearly varia	%	**90%**	Household survey 2010
Grain saved from loss (stored in metal silo)	%	**10%**	Difference with/without metal silo; FAO, PRP, Raboud et al. 1984
Price of maize (corresp. to time of Programme)	US $/t	**200**	FAOSTAT: Mean according to period country programme
Price of beans (corresp. to time of Programme)	US $/t	**640**	FAOSTAT: Mean according to period country programme
Current price of maize (end 2009)	US $/t	**300**	Average retail price (precio mayorista internacional) SICA & USDA
Current price of beans (end 2009)	US $/t	**1000**	Average retail price (precio mayorista internacional) SICA & USDA
B. Tinsmiths: silo production and selling, traders			
Metal sheets used for silo of 18 qq.*	No.	**4.5**	4.5 sheets of 3x6 feet, quality "Postcosecha"
Fraction cost of metal sheets/total material cost	%	**85%**	Bravo, 2009 (attachment 10, page 245)
Cost (tinsmith) for galvanized metal sheet 3x6 long-term	US $	**8.0**	PRP Reports and evaluations
Average silo production cost long-term (1983-2009)	US $	**45**	PRP Reports and evaluations
Average comercial price of silo long-term (1983-2009)	US $	**60**	PRP Reports and evaluations
Cost (tinsmith) for galvanized metal sheet 3x6 f. in 2009	US $	**12.9**	Survey tinsmiths 2010
Total material cost of silo 2009	US $	**68**	Calculated based on fraction metal sheet/total material cost
Calcuated commercial price of silo 18 qq. (2009)	US $	**91**	Coincides with survey data tinsmiths 2010 (Honduras > other)
Gross margin on sold silo (tinsmith)	%	**25%**	Utility + labour + depreciation
Gross margin side products (tinsmith)	%	**10%**	corresp. to 5% of surplus metal sheets sold at double value
Gross margin on sold metal sheet (traders)	%	**15%**	% on galvanized metal sheet price

Table A2.2:. Overview of quantitative impact figures Postcosecha programme Central America
(Detailed calculations: EXCEL, see Annex 12)

Variable	Unit	Guatemala	El Salvador	Honduras	Nicaragua	Total	Source of information / comments
A. General impact (national, aggregated)							
Staple grain producer households (smallholders; 2007))	No.	941'800	325'000	385'100	289'300	1'941'200	Baumeister, 2010
Members per producer household (2007)	No.	6	5.4	5.7	6	5.9	Baumeister, 2010
Total population staple grain producers(=potential beneficiaries)	No.	5'651'000	1'755'000	2'195'000	1'736'000	11'337'000	Calculated from above
Total silos transferred (till end of 2009)	**No.**	**241'000**	**77'000**	**229'000**	**120'000**	**667'000**	Galdámez, 2010, UPC Postcosecha, own verifications
Total silos in use 2009 (≤15 years)	**No.**	**238'000**	**74'000**	**174'000**	**110'000**	**596'000**	Mainly relevant in Honduras (start 1983)
Total households with metal silos (2009; adj. for No. silo/HH)	**No.**	**159'000**	**53'000**	**134'000**	**69'000**	**415'000**	See No. of silos/HH below
Total population with metal silos (= effective beneficiaries)	**No.**	**954'000**	**286'000**	**764'000**	**414'000**	**2'418'000**	No. of silos x members/producer HH
Silo coverage in 2009	**%**	**17**	**16**	**35**	**24**	**21**	calculated from above: silo users HH/staple grain producer HH
Total annual maize production (avg. 2000-2008)	t/year	1'130'000	692'000	527'000	481'000	2'831'000	FAOSTAT database
Total annual grain stored in silos (adj. 95% use/90% filling capacity)	**t**	**139'000**	**49'000**	**122'000**	**68'000**	**378'000**	Total No. of silos in use x average storage capacity per HH; adjustments based on survey results
Grain stored in silo/total stored prod. (base: 75% of prod. is stored)	**%**	**16**	**9**	**31**	**19**	**18**	Calculated from above
Total grain saved from loss in 2009 (base: 10% saved from loss)	**t**	**13'900**	**4'900**	**12'200**	**6'800**	**37'800**	Calculated from above.
Total value of grain saved from loss in 2009 (95% maize,5% beans)	**US $**	**4'170'000**	**1'470'000**	**3'660'000**	**2'040'000**	**11'340'000**	Calculated from above. Prices form FAOSTAT (EXCEL database, sheet 4 +5)
Total grain saved from loss (accum. 1983-2009, 10% saved)	**t**	**88'000**	**38'000**	**150'000**	**60'000**	**336'000**	Calculated from above.
Total value of grain saved from loss (accum. 1983-2009)	**US $**	**19'536'000**	**8'436'000**	**33'300'000**	**13'320'000**	**74'592'000**	Calculated from above. Historic prices form FAOSTAT (EXCEL database, sheets 4 + 5)

Variable	Unit	Guatemala	El Salvador	Honduras	Nicaragua	Total	Source of information / comments
B. Silo users (household level)							
Metal silos/household (2009)	No.	1.5	1.4	1.3	1.6	1.4	Survey 2010
Annual grain stored in silos/ household (adjusted)	kg	870	920	910	990	910	Survey 2010
Grain saved from loss/household in 2009 (base: 10% saved)	kg	87	92	91	99	91	Calculated from above
Value of grain saved from loss/ household in 2009	US$	29	31	30	33	31	Calculated from above
C. Tinsmiths							
Total estimated active tinsmiths (2009)	No.	410	130	180	130	850	Galdámez, 2010 and own estimates (interviews and survey results)
Gross margin tinsmiths (over whole period; 25% margin silo+10% side prod.)	US$	4'034'000	1'432'000	4'350'000	2'093'000	11'909'000	See EXCEL database
Gross margin/tinsmith/year (average over whole period	US$	900	900	1460	1280	1140	See EXCEL database. Considers No. of years tinsmiths have been working
Gross margin/tinsmith/year in 2009	US$	870	2370	1620	1320	1330	See EXCEL database
D. Other socio-econ. indicators							
Total population (2007)	No.	13'700'000	7'100'000	7'200'000	5'700'000	33'700'000	CEPAL/UN; WDI/World Bank 2008
Total rural population (2007)	No.	6'935'000	2'719'000	3'738'000	2'440'000	15'832'000	CEPAL/UN; WDI/World Bank 2008
Total population of basic staple grain producers (2007)	No.	5'650'800	1'755'000	2'195'070	1'735'800	11'336'670	Baumeister, 2010
Total rural population of basic staple grain producers (2007)	No.	4'673'000	1'481'000	2'024'000	1'565'000	9'743'000	Baumeister, 2010
% rural/total	%	51	38	52	43	47	calc. from above
% rural basic staple grain producers/rural population	%	67	54	54	64	62	Baumeister, 2010
Total area staple grains (maize, beans, rice, sorghum)	ha	1092700	421700	495000	698800	2'708'200	Baumeister, 2010
% area maize/area staple grains	%	73	62	73	51	65	calculated from above
Per capita production of maize (white and yellow)	kg	94	118	86	85	96	calculated from above
Per capita consumption of maize (white and yellow)	kg	147	179	101	95	135	calc. from above (Consumption/Population)
Poverty (no cover of basic needs) of staple grain producer families	%	68.5	55.6	90.7	76.2		Baumeister, 2010 (period 2005-2007)
Yearly income rural families 2007	US$	1872	2124	1464	1860		Baumeister, 2010
GNI per capita 2009 (Atlas method)	US$	2650	3770	1800	1000		WDI World Bank

Annex 3: Economic differences between users and non-users of metal silos

Model calculations for different types of famers based on results of the survey (maize use Table A1.10, maize selling pattern Table A1.11, maize prices Table A1.12, and own estimations)

1. Subsistence farmer (type A): harvest of 0.9 ton of maize, 5%/10% sold at harvest, 90% stored in 18 qq.silo / 90% other; 5% selling								
	A. Silo user				B. Non-user			
		kg	US $ /kg	Total		kg	US $ /kg	Total
A. Harvested maize:		900 (20 qq.)				900		
B. Destination of harvest:	Distribution:				Distribution:			
1. Sold immediatley at harvest:	5%	45	0.30	14	10%	90	0.30	27
2. Stored in metal silo:	90%	810						
3. Stored in other facilities:	5%	45			90%	810		
4. Total stored:		855			100%	810		
C. Selling of stored maize:								
1. stored in metal silo	5%	41	0.35	14				
2. Stored in other facilities	0%	0	0.32	0	5%	41	0.32	13
3. Total stored sold:	5%	41			5%	41		
D. Loss:								
1. Lost (10% dif. metal silo vs. other facilities):	10%	5			10%	81		
E. Consumption:								
1. Consumption of stored (in silos and others):	95%	810			85%	689		
2. Consumption equilibrium (diference=need to buy high price)						-122	0.35	-43
Total gain:				**28**				**-3**
Diference:				**30**				

2. Farm type with little surplus selling (type B): harvest of 1.8 tons of maize, 20% sold at harvest, 60% stored in silo, 20% otherwise; 35% of all stored is sold.								
	A. Silo user				B. Non-user			
		kg	US $ /kg	Total		kg	US $ /kg	Total
A. Harvested maize:		1800 (40 qq)				1800		
B. Destination of harvest:	Distribution:				Distribution:			
1. Sold immediatley at harvest:	20%	360	0.30	108	25%	450	0.30	135
2. Stored in metal silo:	60%	1080						
3. Stored in other facilities:	20%	360			75%	1350		
4. Total stored:		1440				1350		
C. Selling of stored maize:								
1. Stored in metal silo	35%	378	0.35	132				
2. Stored in other facilities	35%	126	0.32	40	35%	473	0.32	151
3. Total stored sold:	35%	504			35%	473		
D. Loss:								
1. Lost (10% dif. metal silo vs. other facilities):	10%	36			10%	135		
E. Consumption:								
1. Consumption of stored (in silos and others):	63%	900			55%	743		
2. Consumption equilibrium (diference = need to buy)						-158	0.35	-55
Total gain:				**281**				**231**
Diference:				**50**				

3. Farmer with market access (type C): harvest of 2.7 tons of maize, 30/40% sold at harvest, 60% stored in silo, 10/60% otherwise; 60/70% of all stored is sold.								
	A. Silo user				B. Non-user			
		kg	US $ /kg	Total		kg	US $ /kg	Total
A. Harvested maize:		2700 (60qq)				2700		
B. Destination of harvest:	Distribution:				Distribution:			
1. Sold immediatley at harvest:	30%	810	0.30	243	40%	1080	0.30	324
2. Stored in metal silo:	60%	1620						
3. Stored in other facilities:	10%	270			60%	1620		
4. Total stored:		1890				1620		
C. Selling of stored maize:								
1. stored in metal silo	60%	972	0.35	340				
2. Stored in other facilities	60%	162	0.32	52	70%	1134	0.32	363
3. Total stored sold:	60%	1134			70%	1134		
D. Loss:								
1. Lost (10% dif. metal silo vs. other facilities):	10%	27			10%	162		
E. Consumption:								
1. Consumption of stored (in silos and others):	39%	729			20%	324		
2. Consumption equilibrium (diference = need to buy)						-405	0.35	-142
Total gain:				**635**				**545**
Diference:				**90**				

Annex 4: Cost Benefit Analysis of metal silo

Assumptions:

1. Total duration/lifespan of silo: 45 years. With a lifespan of 15 years, the silo is replaced twice

2. Discount rate: 12% (acc. to interest rates, pers. comm.. F. Pérez, Nitlapan)

3. Silo cost: 90 US $ for first 18 qq. silo. 2nd and 3rd silo (replacement after 15 and 30 years) is +25% each replacement or 113 and 141 US$ per silo.

4. Operation and maintenance:
- Fumigant (phostoxin tablets): 1 US$ per silo filling (3 phostoxin tablets)
- maintenance of silo: repainting oxided parts etc. costs 5 USD after 5 and 10 years.

4. Transfer cost:
Results survey: about 40% of silos transferred directly by tinsmiths, 60% by a transfer institution (Govt., NGO etc.).
Cost per silo transferred institutionally in the range of 125 US$ per silo (Coulter et al., 1995) = 0.6 x 125 = 75 US$ on average all silos.
As for silo price +25% at each replacement (15 and 30 years)

5. Annual benefit of metal silo:
- scenario low: 30 US$ (based on economic model calculations for farm type A and prices year 2009 = year 0). With 1 silo of 18 qq.
- scenario medium: 50 US$ (based on economic model calculations for farm type B and prices year 2009 = year 0). With average of 1.5 silos of 18 qq.
- scenario high: 90 US$ (based on economic model calculations for farm type C and prices year 2009 = year 0). With average of 2 silos of 18 qq.

Benefits are based on the economic calculations per farm type as shown in Annex 3.

1. Scenario low benefit without transfer costs:

		Costs		Benefits		B/C ratio	IRR
	Disc_rate	Total Cost C	OP&M	Benefit	Net benefit B		
NPV	0.12	**102.99**	fumig./year+maint. 5/10 y.		**235.36**	**2.29**	**47%**
Year 0		90.00	1	30.00	29.00		-61.00
1		0.00	1	30.00	29.00		29.00
2		0.00	1	30.00	29.00		29.00
3		0.00	1	30.00	29.00		29.00
4		0.00	1	30.00	29.00		29.00
5		0.00	6	30.00	24.00		24.00
6		0.00	1	30.00	29.00		29.00
7		0.00	1	30.00	29.00		29.00
8		0.00	1	30.00	29.00		29.00
9		0.00	1	30.00	29.00		29.00
10		0.00	6	30.00	24.00		24.00
11		0.00	1	30.00	29.00		29.00
12		0.00	1	30.00	29.00		29.00
13		0.00	1	30.00	29.00		29.00
14		0.00	1	30.00	29.00		29.00
15		113.00	1	30.00	29.00		-84.00
16		0.00	1	30.00	29.00		29.00
17		0.00	1	30.00	29.00		29.00
18		0.00	1	30.00	29.00		29.00
19		0.00	1	30.00	29.00		29.00
20		0.00	6	30.00	24.00		24.00
21		0.00	1	30.00	29.00		29.00
22		0.00	1	30.00	29.00		29.00
23		0.00	1	30.00	29.00		29.00
24		0.00	1	30.00	29.00		29.00
25		0.00	6	30.00	24.00		24.00
26		0.00	1	30.00	29.00		29.00
27		0.00	1	30.00	29.00		29.00
28		0.00	1	30.00	29.00		29.00
29		0.00	1	30.00	29.00		29.00
30		141.00	1	30.00	29.00		-112.00
31		0.00	1	30.00	29.00		29.00
32		0.00	1	30.00	29.00		29.00
33		0.00	1	30.00	29.00		29.00
34		0.00	1	30.00	29.00		29.00
35		0.00	6	30.00	24.00		24.00
36		0.00	1	30.00	29.00		29.00
37		0.00	1	30.00	29.00		29.00
38		0.00	1	30.00	29.00		29.00
39		0.00	1	30.00	29.00		29.00
40		0.00	6	30.00	24.00		24.00
41		0.00	1	30.00	29.00		29.00
42		0.00	1	30.00	29.00		29.00
43		0.00	1	30.00	29.00		29.00
44		0.00	1	30.00	29.00		29.00

2. Scenario medium benefit without transfer cost

		Costs		Benefits		B/C ratio	IRR
	Disc_rate	Total Cost C	OP&M	Benefit	Net benefit B		
NPV	0.12	154.39	fumig./year+maint. 5/10 y.		394.46	2.55	55%
Year 0		135.00	1.5	50.00	48.50		-86.50
1		0.00	1.5	50.00	48.50		48.50

etc.

3. Scenario high benefit without transfer cost

		Costs		Benefits		B/C ratio	IRR
	Disc_rate	Total Cost C	OP&M	Benefit	Net benefit B		
NPV	0.12	205.82	fumig./year+maint. 5/10 y.		719.20	3.49	95%
Year 0		180.00	2.0	90.00	88.00		-92.00
1		0.00	2.0	90.00	88.00		88.00

etc.

4. Scenario low benefit with transfer costs:

		Costs		Benefits		B/C ratio	IRR
	Disc_rate	Total Cost C	OP&M	Benefit	Net benefit B		
NPV	0.12	188.61	(fumig./year+repair 10 yea		235.36	1.25	18%
Year 0		165.00	1	30.00	29.00		-136.00
1		0.00	1	30.00	29.00		29.00

etc.

5. Scenario medium benefit with transfer costs:

		Costs		Benefits		B/C ratio	IRR
	Disc_rate	Total Cost C	OP&M	Benefit	Net benefit B		
NPV	0.12	283.37	(fumig./year+repair 10 yea		394.46	1.39	22%
Year 0		248.00	1.5	50.00	48.50		-199.50
1		0.00	1.5	50.00	48.50		48.50

etc.

6. Scenario high benefit with transfer costs:

		Costs		Benefits		B/C ratio	IRR
	Disc_rate	Total Cost C	OP&M	Benefit	Net benefit B		
NPV	0.12	377.39	(fumig./year+repair 10 yea		719.20	1.91	35%
Year 0		330.00	2.0	90.00	88.00		-242.00
1		0.00	2.0	90.00	88.00		88.00

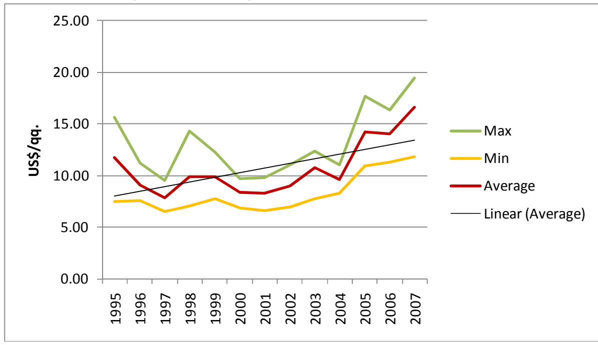
etc.

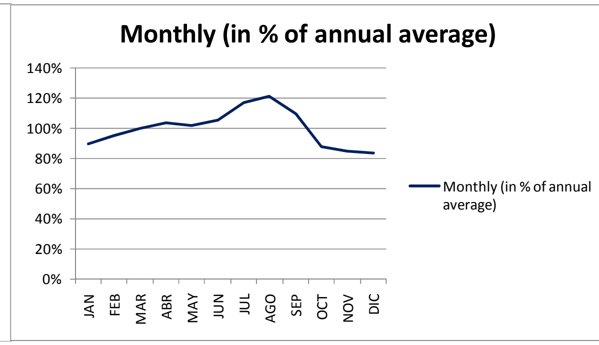
Annex 5: Analysis of effects of maize stored in metal silos on price stabilization

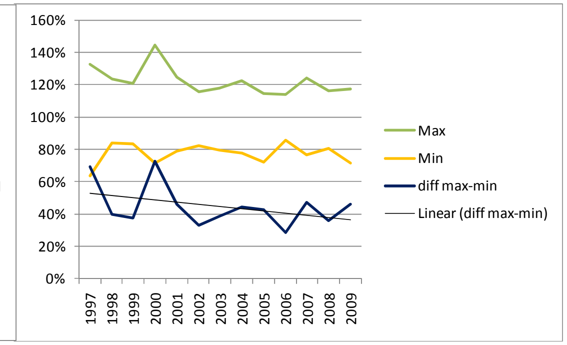
A) Evolution of maize prices (left to right: total prices; seasonal fluctuations in %; minimum, maximum and difference max-min in %)

<u>Honduras:</u> (source of data: SIMPAH-SAG/FHIA):

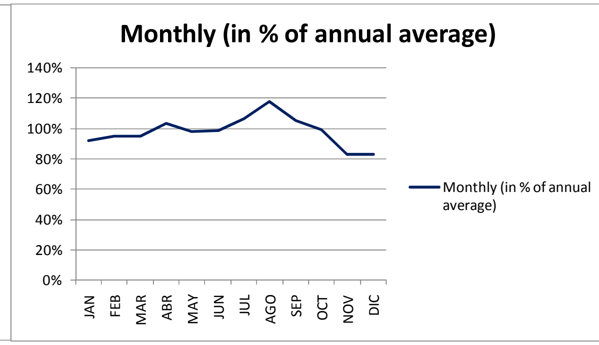
Wholesale prices department Yoro

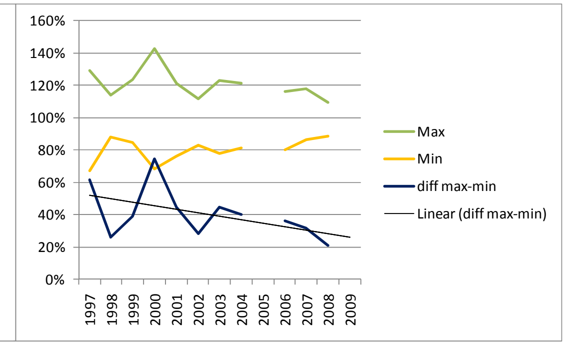




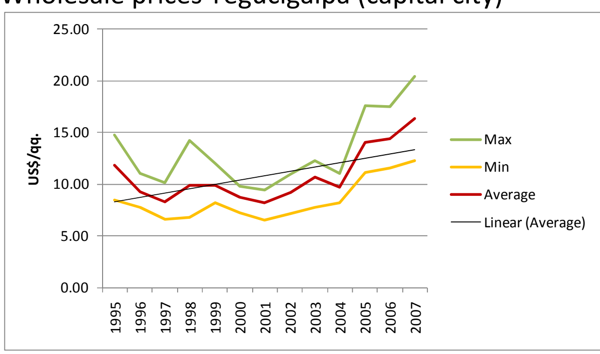


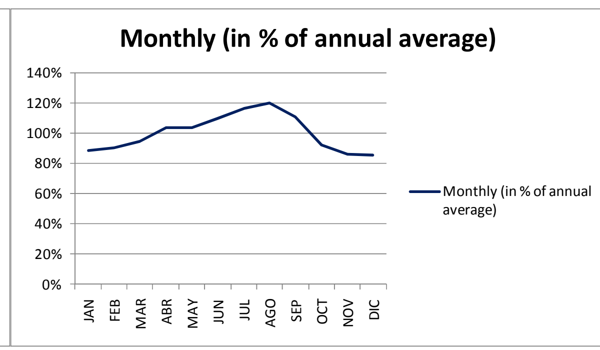
Wholesale prices departments Intibuca/Lempiras)

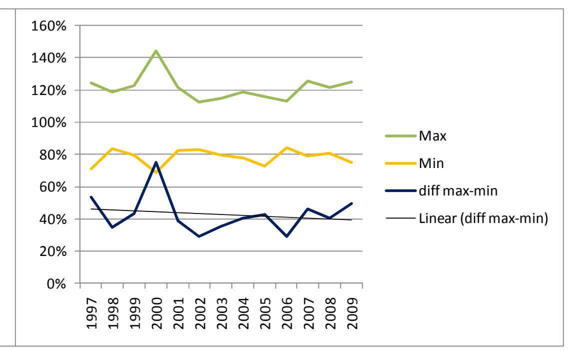




Wholesale prices Tegucigalpa (capital city)

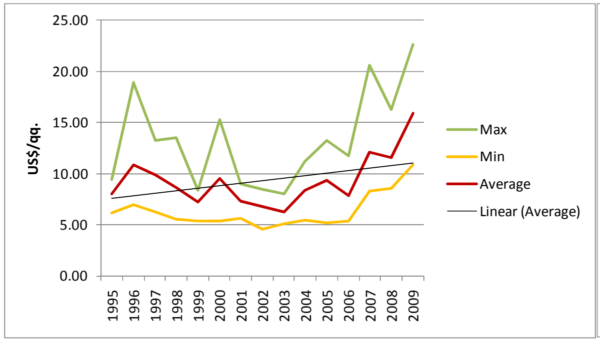


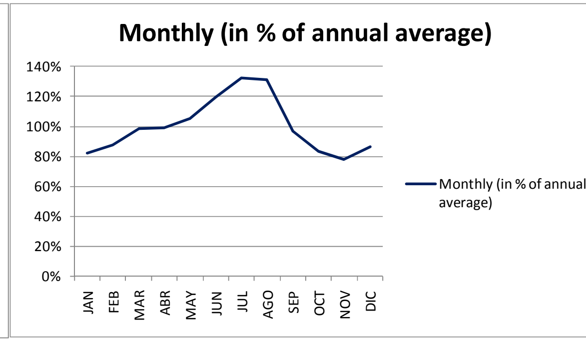


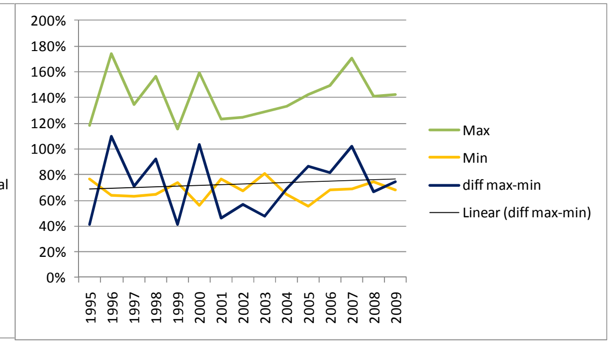


Nicaragua: (source of data: MAG-FOR)

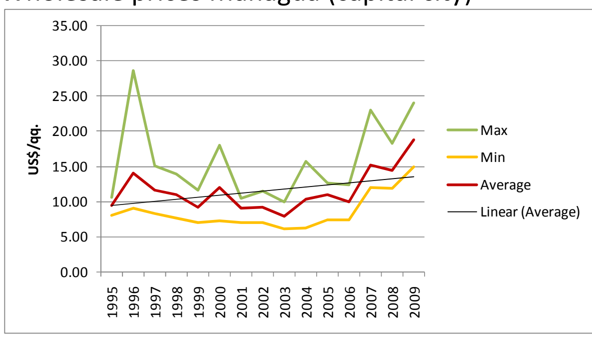
Farmgate prices (national average)

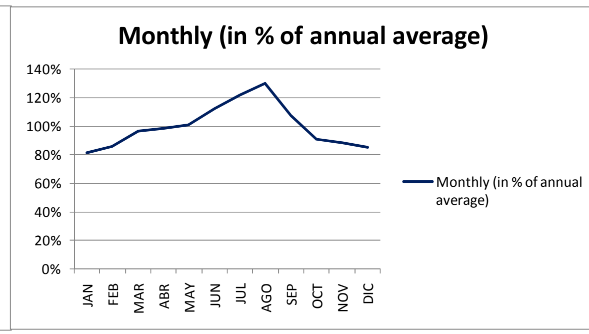


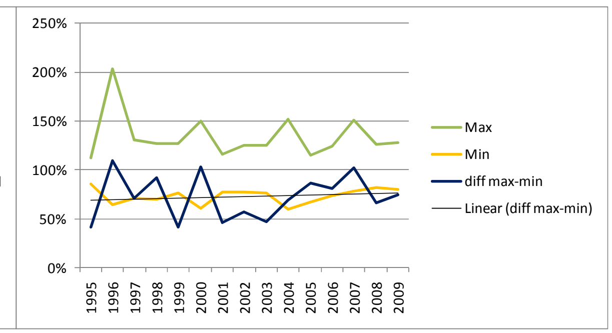




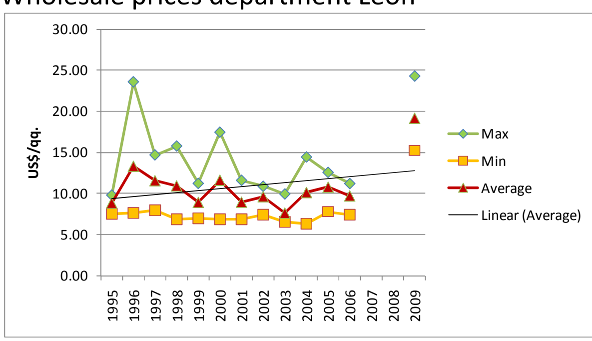
Wholesale prices Managua (capital city)

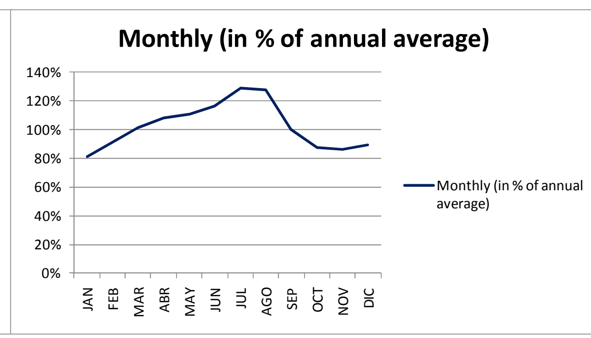


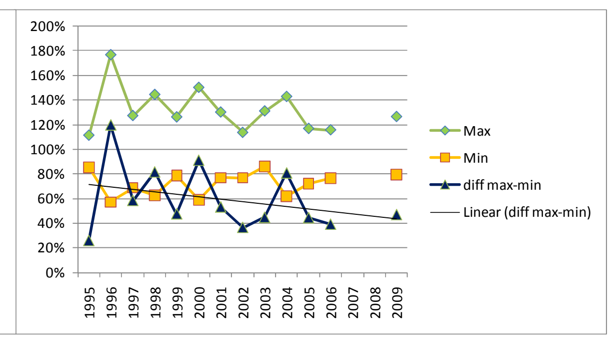




Wholesale prices department León







B) Model calculation price stabilizing effect of maize stored in metal silo

Hypothesis: Critical quantity of maize stored in metal silos has a price stabilizing effect on interseasonal variation through:

1 Withdrawal of maize grain from the market at harvest time when prices are low (e.g. November to February).

2 Selling of an important part of maize stored in metal silos later when prices are high (e.g. in Honduras from May to August)

3 No need for farmers with silo stored grain to buy maize in periods of scarcity when prices are high

			Scenario average (Region)	Scenario high (Honduras)	**Source /comments:**
Assumptions:					
A1	Total annual maize grain consumption (tons):		4'550'000	724'000	CEPAL (see sheet 2b)
A2	Fraction of grain sold before in low season, sold now as stored grain in high season:		20%	20%	Nuñez and Castillo, 1995. Cited in Coulter and Bruessel, 1995, p. 47. Plus own estimates based on survey.
A3.1	Price elasticity of demand (PED of staple grain is inelastic)		-0.25	-0.25	Coulter et. al., 1995: -0.25
A3.2	Price elasticity of demand (PED of staple grain is inelastic)		-0.33	-0.33	Hernandez, 2008: -0.33 for Guatemala
A4	Certain market autarchy: closed markets (no imports/export influence)				More valid at local/regional scale (G. Sain, pers. comm.).
Calculation (all quantities in metric tons):					
1	Mean monthly consumption:		380000	60000	from A1 above
2	Quantity stored in metal silos annually:		380000	122000	from survey, Annex 2, Table A2.2
3	Increase in storage by farmers (4 months period):		76000	24400	Total annual stored and A2 above
4	= Monthly quantity of grain withdrawn from market:		19000	6100	25% of 3)
5	Increase in monthly offer of grain in high season:		19000	6100	iden
6	Increase (%) of monthly offer/monthly demand:		5	10	5) div. 1) in %
7	Price change (%): (increased demand/price elasticity):	for PED -0.25	-20	-41	6) div. A3.1
		for PED -0.33	-15	-31	6) div. A3.2

Annex 6: Detailed description of the methodology

1. Impact hypothesis

General impact hypothesis Postcosecha:

The production by tinsmiths and use of the metal silos by small and medium farmers causes a significant change in food security and livelihoods of silo producers and silo users, which in turn contributes to an impact at national level (increase in income and food security)

2. Approach and methods for data collection

The ***ex-post* impact study** combined the following methods to verify existing data and to assess the impact of the *Postcosecha* programme:

- Establishment of an **inventory of existing documents/data and its verification**, especially for the period 2000-2009 and prioritize the most relevant information for the study.
- Implementation of a **survey** in 4 countries at different levels: farmers, tinsmiths, key institutional informants
- Conduct **interviews** with key experts and institutions to assess the factors of success/failures of the Postcosecha intervention model.

2.1. Inventory of existing documents/data and its verification

With the support of the ex-Postcosecha collaborator René Galdámez, relevant information on the functioning of the Postcosecha Programme with emphasis on the period 2000-2009 including a database for tinsmiths and silo transfers was established. A detailed report produced (Galdámez, 2010) provided valuable information for the selection of the survey area, namely:

- List of active tinsmith, based on list year 2002 (source Postcosecha Units)
- List of organizations involved in silo distribution at the end of 2002-2003 (source Postcosecha Units)
- Silo distribution at the end of 2002 (source Postcosecha Units)
- List of silo distribution of 2003-2009 (based on estimations coming from key organizations involved in silo distribution)
- Updated list of experts and organizations involved in silo distributions (2003-2009)

This information was further corroborated by interviews with key informants and results from the field survey.

2.2. Survey

a) Tinsmiths

Sampling approach: According to current information available about 900 tinsmiths are thought to be active producers of metal silos (Galdámez, 2010). However, due to lack of follow-up, in Nicaragua and Honduras the selection had to be based on old (2003) list of active tinsmiths.

Criteria for the selection and classification of tinsmiths to be interviewed:
1. Located in major maize production zones. Major maize production zones per country are regions where harvest is concentrated annually (region and department).
2. Experience: More than 1 year of experience (i.e. tinsmiths who started silo production in 2009 only are excluded from interview)
3. Classification by type of tinsmith:
    a. Micro: farmer-tinsmiths (on average <50 metal silos produced/year),
    b. Small: artisan tinsmith (50-200 metal silos/year
    c. Medium: small enterprise tinsmiths (200-500 metal silos/year)
    d. enterprise tinsmiths (> 500 silos/year)

Sampling steps (stratified random sampling):
1. **Totals sample size: 100** tinsmiths will be interviewed corresponding to approximately 10% of the total of active tinsmiths.
2. **Proportional allocation of tinsmiths per country** (based on list of tinsmiths as per year 2002): Given that information on the proportional distribution of tinsmiths between the countries is available, a proportional sample size per country is selected, i.e. 30 each in Guatemala and Honduras and 20 each in Nicaragua and El Salvador.
3. **Proportional allocation of tinsmiths per zone**: at country level a proportional sample size according the distribution of tinsmiths in major maize production zones is selected (see Table below). The sample will be distributed proportionally in order to calculate the number of cases to be interviewed in each zone.
4. **Random sampling** for individual tinsmith interviews: Final selection of tinsmiths to be interviewed was done at random from an established list of tinsmiths per zone (identifying municipalities and communities of residence). It should be pointed out that in practice various tinsmiths were substituted because when contacted they had converted to other work, died or left the country etc.. The number of tinsmiths substituted in each country was as follows: Guatemala (4/33), El Salvador (0/20), Honduras (3/24) and Nicaragua (5/22). Therefore, not all tinsmiths listed in the database can be considered to produce metal silos (while others may not be registered in the database).

b) Silo users and non-users

Sampling approach: Cluster sampling in multi-stages is used as the most appropriate random sampling method, based on the given situation:
1. No list of the population exists (e.g. list of silo users after 2002 does not exist)
2. Well-defined geographic areas can be delimited
3. A reasonable <u>estimate</u> of the number of silos at cluster level can be made (however, data is not available after 2002).

Criteria applied for clustering and selection of respondents (silo users and non-users):

1. Major maize production zones in each of the 4 countries.
2. For Guatemala: ethnic origin (zones of indigenous and mestizo population)
3. Farm size: Small and medium maize farmers up to 15 mz. (10.5 ha) of own land (bigger farmers did not belong to the main target group of Postcosecha and were excluded).
4. Type of grain stored: Former studies (e.g. Gladstone et al., 2002) showed that the big majority of farmers buy a metal silo to store maize; some of them also buy a second metal silo to store bean seed. Therefore, the survey concentrates on farmers storing primarily maize grain, dividing the silo user and non-user group as follows:
    a. farmers producing maize and store it in metal silos (beans considered if applicable)
    b. farmers producing maize but do <u>not store maize in metal silos = comparison group</u> (beans considered if applicable)

Sampling steps: (Cluster sampling in multi-stages):

1. **Sample size:** Based on the above approach a sample size of 200 metallic silo users per country with an equal sized comparison group (p=0.5) was defined; in total 800 silo users and 800 non-(metallic) silo users. Based on an estimate of 400'000 silo users, this corresponds to 0.2% of the population with silos. Confidence level: 99%; Error (confidence interval): 10%.
2. **Random selection of silo and non silo users:** In each municipality where tinsmiths had been selected, a list of communities was established and one community was selected randomly. In each community selected two lists of producers: one of metal silo users and one of non-silo users were established with the help of local leaders/stakeholders applying the defined criteria. From each list the farmers to be interviewed were selected randomly (proportional sample according to No. of tinsmiths per department, see Table below). That way, each major maize production zones will count with a proportional sample of silo users and non users to be interviewed, according to its relative weight of tinsmith's number by zones[1].

Conduction of survey: Interviews with the tinsmiths and producer households (where available with the couple) were conducted based on pre-tested questionnaires (see Annex 7). 25% of the interviews at farm households was conducted with women.

[1] The evaluation design corresponds to "Post-test comparison of project and comparison group" which is considered as a (less) robust quasi experimental design. However, due to time, cost and data availability constraints, we used a random selection of households and not the more rigorous method of matching on observables (Nearest neighbour; Propensity Score Matching).

Distribution of the sample of tinsmiths and producer households

Country	Region	Department	Active	Sample	Sample	Sample	Total sample
Guatemala	Region IV	Jutiapa	30	8	49	49	98
	Region III	Chimaltenango	35	10	57	57	114
	Region VI	San Marcos	21	6	34	34	68
	Region VII	Alta Verapaz	37	10	60	60	120
Sub Total			123	34	200	200	400
Honduras	Region 2	Intibuca	9	2	21	21	42
	Region 3	Yoro	21	6	48	48	96
	Region 7	Lempira	43	12	99	99	198
	Region 1	Choluteca	14	4	32	32	64
Sub Total			87	24	200	200	400
El Salvador	REGION IV	Morazan	27	7	74	74	148
	REGION II	Cuscatlan	14	4	38	38	76
	REGION IV	Usulutlan	20	5	55	55	110
	REGION III	Cabanhas	12	3	33	33	66
Sub Total			73	20	200	200	400
Nicaragua	Central Norte	Matagalpa	31	9	79	79	159
	Pacifico Norte	Leon	19	5	49	49	97
	Segovias	Esteli	16	5	41	41	82
	Centro sur	Nueva Guinea	12	3	31	31	62
Sub Total			78	22	200	200	400
Total sample for survey				**100**	**800**	**800**	**1600**

2.3 Expert interviews

A total 37 expert interviews (see list end of Annex 8) were conducted with key informants of institutions involved in the dissemination of silos (experts in postharvest technology and transfer, value chains and marketing) and with selected experts having "a wider perspective" on food security and agricultural policies in general. These informants were mainly from Central America with a few persons form elsewhere (direct interviews in Central America or via Skype). These interviews provided provide further insights to understand the key success factors and limitations of the impact model in the context of Central America (and a few replication experiences conducted elsewhere), and the implications for further dissemination of the Postcosecha approach. The expert interviews will analyse the following critical elements/factors of the impact model:

- **Technology, production & dissemination chain**: Availability of raw materials at affordable price, quality of silo, labour availability, storage diligence, and effective extension services.
- **Business model based on market-mechanisms and public-private partnership**: public funds used to cover costs for coordination/management, extension & training; private funds for supply of raw materials, production and purchase of silo, and provision of credit for production and purchase. Impact of subsidized silo distribution schemes (Government, NGO).
- **Management structure:** how to reduce transaction costs; create synergies/win-win solutions.

(List of interviewed persons at the end of Annex 8)

3. Data analysis

In a **first step**, simple statistical analysis (frequencies, means comparison etc.) for the variables listed below was conducted using the SPSS (PASW version.15) applying t- and F-tests. Comparison between silo users and non-users was further refined by a stratification of producers based on the ratio of maize production and maize consumption indicated by interviewed farmers for the year 2008[2] as follows:

$$\textbf{Type}_{(A,,B,C)} = \frac{\text{Annual farm maize production (P)}}{\text{Annual household maize consumption (C)}}$$

whereby:

Type A: P/C ≤ 1. Subsistence farmers without market integration. Purpose of silo use is food security. These are rural households that have difficulty covering their own consumption needs even in regular production years. Thus, they are the most vulnerable sector and net grain buyers.

Type B: P/C >1 and ≤3. Subsistence farmers with low market integration. Main purpose of silo use is food security, with selling of maize stored in silos being less important. These are rural households that manage to cover their own consumption needs for maize and even to sell a small surplus in regular to good production years. However their access to the market is fragile and greatly depends on favorable agro-climatological conditions.

Type C: P >3. Small to medium farmers with moderate market integration. Selling of maize stored in silos is important. These are rural households that, in addition to easily covering their own needs for maize cannsell important grain surpluses in regular to good production years, thus giving them better market insertion.

The 3 types is a pragmatic way of using one single indicator to classify farms in the 4 countries which cannot be easily classified on same assets (e.g. farm size: poor farmers in Nicaragua and Honduras own more land than e.g. in Salvador, where maize production is more intensive…). The C/P ratio serves as proxy mainly for food security (and less for wealth) considering storage of maize in metal silo has as main purpose to increase food security (ref. Postcosecha project objective).

Perceptions were captured and analyzed using ratings using a Likert scale 1-5 (e.g. for livelihood conditions). Aggregate impact figures at national scale was done based on survey results and other statistical sources, (FAOSTAT, Ministries of agriculture in the four countries etc.) and literature.

Variables analysed	Description

[2] The year 2008 was considered more representative compared to 2009 since many farmers indicated to have had an exceptionally bad harvest in 2009.

Variables analysed	Description
1. Target group / level: Farmers / silo users	
1.1 No. of silos in use per household	• Average No. of silos used per household (acc. to silo size), Use of metal silo (type of grain stored) • Confirmation of duration of use of metal silo • Use of alternative storage methods.
1.2 Adoption (or not) of metal silo	• Reasons for acquisition (or not) of metal silo • Decision-making for acquisition of metal silo • Channel of acquisition • Cost of silo and payment modality
1.3 Quantity of grain stored	• Quantity and type of grain stored per household / year (in metal silo or other storage facilities)
1.4 Quantity of grain saved from loss	• Confirmation of estimation of grain saved from loss (10-15%: needs to be confirmed by silo users, etc.)
1.5 Food security	• Availability of food (physical/econ. access) per household (months/year); availability of food in most critical months.
1.6 Additional income/cost savings	• Estimation of additional income generated from grain saved from loss or selling at better prices. • Approximate cost-benefit analysis of silo[1]
1.7 Livelihood improvement (socio-economic wellbeing)	Includes aspects like: food security, housing, investments, education of children, health/hygiene, workload of women, social status in community, importance of silo in disaster situations). This information will be quantified by using Likert scale ratings
2. Target group /level: Tinsmiths	
2.1 No. of active tinsmiths	Provided by updated database, to be verified (active vs. non active).
2.2 No. of silos produced/delivered	• Total number of silos produced and delivered over years / countries (acc. to silo size). ➔ Calculation of total No. of silos delivered and total No. of households using silos (combined with variable 1.1). • Production of other related products (hojalateria)
2.3 Commercialization of silos	• Persons selling (gender), clients, sales channels • Paying modalities, prices • Bottlenecks in commercialization
2.4 Income and employment, investments	• Increase of employment due to production of silos and other products; increased business due to innovations (e.g. other products) • Additional income generated due to production of silos or other related tinsmith products; • Use of additional income (investments).
2.5 Livelihood improvement	• As for farmers (with minor modifications, e.g. investment in business.
3. Target group / level: Institutions / Governments	
3.1 Importance for Governments	Effect of programme on national food security policies. Important factors & framework conditions for further dissemination of approach. Analysis of subsidy model in Guatemala.
4. Target group / level: Context / National economy	
4.1 Food storage capacity	Total quantity of grain stored and saved from loss in improved silos.
4.2 Value generated from grain saved from loss	Total additional value generated in each country due to grain stored and saved from loss.
4.3 Effects/importance of grain stored	Comparison of additional stored/saved grain vs. total production, consumption and imports; analysis of effect of stored grain on price stabilization/fluctuations (price elasticity, free trade influence, etc.).

[1] A full cost-benefit analysis is beyond the scope of this study. Indications of C/B are found in impact study of Coulter et al. (1995) suggesting that the IRR highly depends on many assumptions difficult to monetarize (i.e. benefits in addition to savings from grain not lost). However, an attempt to provide a simple C/B will be made if possible.

In a **second step**, amore in-depth analysis was conducted using regression analysis and other models outlined in the following. The results of this in-depths analysis but will be published in a journal article.

Investment decision model

To explain households' investment in metal silos, we employ a model which considers the investment decision as a two-stage process: first, the decision to invest or not invest; and second - if the decision is to invest - how much to invest. To this end, the so-called double-hurdle model will be employed (Cragg, 1971; Urutyan et al., 2007).

According the double-hurdle model , the households' investment decisions can be formulated as follows:

$$\mathbf{i}_j = \begin{cases} \mathbf{i}_j^* & if \quad \mathbf{i}_j^* > 0 \quad and \quad \mathbf{d}_j = 1 \\ 0 & if \quad \mathbf{i}_j^* \leq 0 \quad and \quad \mathbf{d}_j = 0 \end{cases} \tag{1}$$

where $\mathbf{i}_j$ is observed level of investment (i.e. storage capacity of metal silo(s) acquired by a household), $\mathbf{d}_j$ is the discrete variable describing the decision to invest or not and j is the household index.

$\mathbf{d^*}_j$ is a latent variable (1 – to invest, 0 – not invest) defined by means of a binominal model[3] and $\mathbf{i^*}_j$ is a latent value of the level of investment estimated by means of a truncated regression model, viz:

$$\mathbf{d}_j^* = \varphi' \mathbf{z}_j + \theta_j \tag{2}$$

$$\mathbf{i}_j^* = \beta' \mathbf{x}_j + \varepsilon_j \tag{3}$$

where $\theta_j \sim \mathrm{N}(0,1)$ and $\varepsilon_j \sim \mathrm{N}(0, \sigma_\varepsilon^2)$. $\mathbf{z}_j$ and $\mathbf{x}_j$ are the vectors of explanatory variables in binominal and truncated regression models, respectively.

Accordingly, in our empirical analysis we employ two dependent variables: a binary variable signaling whether a particular household acquired a metal silo in the period from 2005 to 2009 or not, and a further variable which represents the capacity of the respective metal silo(s).[4] The vector of explanatory variables consists of different socio-economic characteristics of surveyed households and is summarized in Table A1 (Appendix).

Modeling impact of metal silo adoption

The impact of the use of silos is investigated by focusing on 3 main fields: a) food security, b farmers' (and their families') well-being and c) sales of maize. We employ standard regression model to assess how the metal silo adoption influences food security and sales of maize.

Food Security

To assess differences between silo user and non-user with regard to food security, farmers were asked how many months they had to buy (i.e. in addition to their own production) maize and beans. These questions covered the years 2008 and 2009. The average value of both years is used in the subsequent analyses. The investigated hypothesis is that silo users need to buy less staple grains from the market, but rather can use their own production due to better storage capacities (Hannes, 1991; Coulter et al., 1995; Gladstone et al., 2002). In a first step, empirical density functions of users and non-users are presented for each of the four countries (Guatemala, El Salvador, Honduras, Nicaragua). Because maize and bean production and consumption differ across these countries, we use a regression analysis to test if silo users in general need to

[3] In this paper we employ a logistic regression.

[4] In the truncated regression, we use the Box-Cox transformation of the dependent variable.

buy less maize and beans[5]. To this end, the numbers of months farms need to buy maize and beans ($Months_C$) are regressed against dummy variables for countries ($D_{Country}$, Guatemala is chosen as reference category), for silo non-use (the use of silos is the reference category) as well as interaction terms between both dummy variables, while β_0 is the regression intercept:

$$Months_C = \beta_0 + \beta_1 D_{Non-User} + \beta_2 D_{Country} + \beta_3 D_{Non-User} * D_{Country} \quad (4)$$

Livelihoods

To assess the impact of silos on non-economic factors (e.g. health, gender and education issues) as well as on factors that are difficult to quantify (e.g. income), farmers asked how their situation changed in the last years with regard to the following variables: the family's food situation, the family's income situation, the workload of women's, children's health situation, and the children's education situation. Thus, the questions covered aspects from various important fields, i.e. improvements in economic, food security, gender and children's situation aspects are considered. The answer scale ranges from 1 (high improvement) to 5 (severe worsening), while 3 indicates no changes. The category 6 was used if the interviewed indicated 'I don't know'. We test the hypotheses that silo users faced a better economic and social development. This is motivated by the fact that the silo adoption generates more financial and less workload as well as that silo users are more resilient to certain shocks (e.g. price fluctuations, bad harvest). In a first step, cross tables and Pearson Chi-Square tests are used to identify if significant differences between users and non-users exist. In a second step, regression analyses are used to also consider country specific effects (and interaction terms) following the methodology described in Equation 4.

Sales of Production

Stored and unstored grain are expected to differ with regard to the timing and location of their sale as well as with regard to the distribution channel. These differences are also expected to cause differences in the received grain prices for different storage technologies. The analyses presented in this section are focused on maize because it is the most important crop for the interviewed households and results for beans indicate similar effects.

To investigate if the location of maize selling is affected by the storage technology, the questionnaire included the question where maize was sold. Answer categories are as follows: the (own) farm, in the village, at the road, in the main city, and others. Following the same structure, it was asked to whom the maize was sold. More specifically, the following answer categories have been used: intermediates, retailers, super market, farmers' organization, direct selling to consumers, and others. Furthermore, farmers indicate in what month they mainly sold the maize and what price they received on average. All questions were asked separately for the different categories of maize storage: for i) unstored maize ii) maize stored in metal silo and iii) maize stored in other storage system.

For unstored maize, i.e. maize that is sold mainly directly after harvest, no difference between metal silo user and non-user are expected in selling location and time, purchaser and price. In contrast, we expect differences between unstored and stored maize, because maize storage in general enables farmers to decide tactically where, when and to which price maize is sold. Furthermore, we expect that maize stored in metal silos can be kept longer than traditionally stored maize. Thus, the time of selling as well as the price is expected to differ between these storage types. In order to test these hypotheses, we use cross tables and Pearson chi-square tests. In addition, group comparisons are conducted using the Mann-Whitney test. To test if maize prices

[5] We included a control question how many months the own production of maize and beans was sufficient for family food provision. This variable confirmed the here presented results.

from different storage systems lead to different prices, we use regression analysis that also accounts for country specific price differences:

$$Price = \beta_0 + \beta_1 D_{Storage\ Type} + \beta_2 D_{Country} \quad (5)$$

The dummy variable for the storage type ($D_{Storage\ Type}$) use unstored maize as reference category, while Guatemala is used as reference category for the country dummy ($D_{Country}$). Note that price data was only indicated by some farms and interaction terms are thus not considered due to the lack of freedom in specific category combinations. All prices were given in local currencies and are converted into US$/qq in the here presented results.

Finally, to identify key factors for successful replication of the Postcosecha experience in other continents, the following issues will be analysed mainly on the base of information obtained in the expert interviews:

- Similarities and differences between Postcosecha **implementation processes in each country** and differentiated interpretation of respective the results — shed light on the evolution of the approach and identification of success factors and limitations.
- **Contextual analysis** (analysis and implications of the local economic, political, institutional and socio-cultural context in each country) in order to understand how local factors might affect/influence further adoption and up-scaling
- outcomes and to which extent they have general validity for replication of Postcosecha elsewhere.
- Strengthen the **validity of projections** of the conditions under which the programme could be replicated.

Annex 7: Questionnaires used in survey

(Note: translated from original in Spanish)

A) **Silo users** (a similar format was applied for non-users, not shown)

INTERCOOPERATION
NITLAPAN-UCA
ETH

Questionnaire No. [ ]

HOUSEHOLD SURVEY: USERS OF METAL SILO

IMPACT STUDY 5 YEARS EX-POST OF POSTCOSECHA PROGRAMME SDC CENTRAL AMERICA 2004-2009

Name (First and last name) of interviewee(s):
1.____ 2.____

Country: __________________

District: ____________________________

Municipality ________________________________

Community: ________________________________

Ethnic group to which the interviewee belongs to:____

Name of interviewer: ____

Name of supervisor: ____

Date of interview: ______day/_______month/______year

Time of questionnaire filling. Time of beginning the survey: ______ Hour of conclusion of the survey: _____

I. GENERAL INFORMATION OF THE FAMILY AND PRODUCER´S FARM

1. How many people live in the household? (eat from same kitchen):__________
2. Characteristics of interviewees (register all people of the household above 12 years of age)

Name Fill name and last name of people above 12 years of age	Position in household	Sex	Current Age	Last school year concluded	Is agriculture the main activity?	What is another type of activity you work in?
C1	C2 1. Head, 2. husband/wife 3. Son 4. Daughter 5. Father 6. Mother 7. Other family member (specify)	C3 1.M 2. F	*C4* *Years completed*	C5 1. None 2. Primary school 1-6 3. Secondary school 7-11 4. Technical education 5. University 6. Professional 7. Alphabetized 8. Another, specify	C6 1. Yes 2. No	C7 1. Trade (specify) 2. Handicrafts (specify) 3. Services 4. Agricultural employed 5. Urban employed 6. Housework 7. Study 8. Another activity (specify)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

3. How many children between 7 and 12 years of age live in the household? _______
4. How many of them go to school? No. of boys________ No. of girls________
5. How many children of less than 7 years of age live in household? No. of boys < 7 years: _______ No. of girls < 7 years:________.

6. Indicate if you have in your household the following (quantity):

1. Bicycle: _____
2. Motorcycle: ____
3. Light trucks: ____
4. Televisions: ____
5. Cellular phone: _______
6. Sound equipment: _______
7. Other, Specify: _______

7. which are your monthly expenses for:

1. Potable water:_______
2. Electricity (light):______
3. Telephone:________

II. FARM CARACTERISTICS AND AGRICULTURAL PRODUCTION

1. Land

Which is the main activity to which you are dedicated in the property? 1. Basic grains 2. Coffee 3. Cattle 4. Vegetables 5. Others	How many farms/plots do the family own?	How much is the total area you own in all the property? (mzs)	Do you rent or lend a plot of land to seed basic grains? 1. Yes 2. No	How many mzs did you rent or lend last year?	Since when do you rent or lend a plot of land to seed grains?

2. Access to services for production and training in last 5 years

Have you received technical attendance for grain culture? 1. Yes 2. No	Have you received any training for handling after harvesting? 1. Yes 2. No	In what subjects were you trained? 1. Drying Techniques 2. Storage Technique 3. Other (specify)	Who received the training subject? 1. Husband 2. Wife 3. Both 4. Other (specify)

3. Evolution of main producer assets

How had change the following assets at the long time?	2009	2008	5 years ago (2004)	Before acquire the silo	Observations on the changes
Land (mz)					
Head cattle					
Plantation (coffee, cacao)					
Pigs (Number)					

4. Evolution of maize and bean production

How had change the grain production in the last years?	2009	2008	5 years ago (2004)	Before acquire the silo	Observations on the changes
Area cultivated with maize (mz) in year					
No. of harvests of maize for year					
Total production of maize obtained in the year (qq)					
Area cultivated with beans (mz) in year					
No. of harvests of beans for year					
Total production of bean obtained in the year (qq)					

III. ADOPTION AND MANAGEMENT OF METAL SILO

1. Acquisition of silo
   - 1. In which year did you get your first metal silo? ________
   - 2. Did you have to replace or repair a silo because it was getting too old or was too much used: 1. Yes:____; 2. No:____
   - 3. How many metallic silos do you have currently? _________(Fill the table)

From what size are the metallic silos that you have?	Quantity of silos that you have from that size	Age of silo (in years)	What do you have store in the silo(s): 1. Maize 2. Beans 3. Both 4. Nothing 5. Other(specify)	How many silos have label (poster) post harvest	Through whom did you get the metal silo? 1. Direct form tinsmith. 2. NGO (name)). 3. Private company (name) 4. Government 5.Cooperative 6.(Other):______	How did you get the silo? 1. Donated 2. In concession 3. Subsidized 4. Bought in cash 5. With credit 6. Other (specify)	If not donated or subsidized (1 and 2), what was the price of acquisition of the silo?	Observation on actual condition of silo (maintenance): 1. Good 2. Regular 3.Bad
Silos 4 qq								
Silos 8 qq								
Silos 12 qq								
Silos 18 qq								
Silos 30 qq								
Otro:____								

4. Why did you decide to get a silo? ➔ various option possible 1. Excessive grain was lost 2. To sell grain at a better price 3. Nowhere for storage 4. Given facility to acquire a silo 5. To try another method. 6. Other reasons, (specify)	5. Who decided to get the silo? 1. Husband 2. Wife 3. Both 4. Son 5. Daughter 6. Other (specify)	6. What results or advantages did you get with the use of the metal silo? (key 1) ➔Multiple answers possible 1. Reduction of loss after harvest 2. More grain available for the family 3. Better price at the time of selling 4. The maintenance is easier than with other systems 5. Less exposure to agrochemicals 6. Better hygiene /house is more clear 7. Others (specify):	7. From the previous advantages or results, what is the most important result or change you have seen? (mention one option)	8. What is the main disadvantage you have observed that a metallic silo has?

2. Postharvest and silo management

Postharvest activity	Who assumes the activity 1. Husband 2. Wife 3. Both 4. Son 5. Daughter 6. Others (specify):	Explications (if needed)
Harvest of grain		
Threshing of maize / of beans		
Filling silo		
Treatment (with tablet example: Fostoxin)		
Emptying silo		
Cleaning silo		

3. Other storage systems

What other types of storage systems/ structures do you have? 1. barn 2. metallic barrel 3. plastic barrel 4. big box 5. tabanco 6. sacks 7. Others (specify)	How many of them (No.)	Unit cost (local currency)	Age (in years of use)	What type of storage grains do you mainly have in them? 1. maize 2. beans 3. sorgo millón 4. rice 5. maize and beans 6. others	Why do you still have these storage systems (explain)

IV. STORAGE OF GRAIN AND ITS DESTINY

1. Storage

Note: Base of following Table is a regular or good maize harvest of year 2009. If the production in 2009 was bad, then take the year 2008➔ indicate year:____ 2009; _____ 2008

Grain	From the total production what quantity of grains was sold at the time of the harvest or consumed immediately (qq shelled)	What quantity of maize produced grains was stored in metallic silos? (qq shelled)	Destiny/use of the storage grain (based on the total stored in qq)				% of lose that had the grain stored in a metallic silo	In a regular year maize harvest, do you fill your (s) metallic silo (s)? 1. Always 2. Almost always 3. Rarely 4. Never
			Sale	Seed	Familiar consumption and fatten of animals	Other 1. Rob 2.Transference		
Maize								
Bean								

Grain	What quantity of grain was stored in other types of storage systems? (qq threshed)	% of lose estimate of grains with other (s) types of systems (%)	Destiny/use of the storage grain (based on the total stored in qq)			
			Sale	Seed	Familiar consumption and fatten of animals	Other 1. Rob 2.Transfference
Maize						
Bean						

2. Sales of grain stored and not stored: MAIZE (take destiny production from previous Table)

Stored grain	Month (s) in which you sold mainly	Total quantity sold (qq shelled)	Average price received for qq	Where did you sell? 1. Farm 2. In village 3. in the Road 4.Main city 5. Other:___	To whom did you sell? 1. Intermediaries 2.Commercial house (empresa de acopio) 3. Supermarket 4. Farmers organization 5. Direct to consumer 6. Other (specify):_______
Grain not stored or sold at the time of the harvest					
Grain stored in metal silo					
Grain stored in other storage systems					

3. Sales of grain stored and not stored: BEAN (take destiny production from previous Table)

Stored grain	Month (s) in which you sold mainly	Total quantity sold (qq shelled)	Average price received for qq	Where did you sell? 1. Farm 2. In village 3. in the Road 4.Main city 5. Other:___	To whom did you sell? 1. Intermediaries 2.Commercial house (empresa de acopio) 3. Supermarket 4. Farmers organization 5. Direct to consumer 6. Other (specify):_______
Grain not stored or sold at the time of the harvest					
Grain stored in metal silo					
Grain stored in other storage systems					

V. IMPACTS

1. Employment

1. How many people (less than 18 years old) from your family have migrated out of the farm to look for a job in or out of the country during the last 5 years?	
Man	Women

Year	2. How many permanent workers do you have in your farm?		How many temporary workers do you have in your farm?	
	Man	Women	Man	Women
2009				
Since years ago (2004)				
Before acquire the silo				

2. Incomes

1. Have you and your family bought electric- household, made improvement in the house, the property (purchase of equipment, infrastructure) or purchase of land and cattle in the last 5 years?

    1. Yes (Fill the table)
    2. No (go to another question)

Type of investment made (key 1)	Who decided to make the investment (Key 2)	Year did you make the investment	Investment Estimated value (in local currency)	¿With which resources did you finance the investment? (Key 3)

Key 1
1. Purchase of household appliances
2. Home improvement
3. Purchase of equipment for the farm
4. Improvement of the infrastructure of the farm
5. Purchase of land
6. Others (specify_____)

Key 2:
1. Husband
2. Wife
3. Both
4. Other (specify)

Key 3.
1. With resources from the farm
2. With resources banks loans, microfinance
3. Otro (specify____)

3. Food Security

MAIZE

1. What are your familiar necessities of maize consumption in the year? (qq) _______
2. Normally, the farm production maize meets the necessities of your family consumption during the year?______

1. Always
2. Almost always
3. The great part
4. Only a small part

Año	From the production stored, how many months did it take to the family consumption in the year?	Did you buy this type grain to feed your family? 1. Yes 2. No	For how many months did you buy?	If you had to buy, with what money did you buy in the year 2009? 1. Money obtained from the farm 2. Money gotten from work out of far 3. Remittance 4. Loaning 5. Another	Why did you have to buy this grain? 1. Bad harvest 2. Limited storage capacity 3. They sold all the harvest because of an emergency 4. Limited land for sowing 5. Limited sowing 6. Other
2009					
2008					
5 years ago					
Before acquire the silo					

BEAN

3. What are your familiar necessities of bean consumption in the year? (qq) _______
4. Normally, the farm production bean meets the necessities of your family consumption during the year?______

1 Always
2 Almost always
3 The great part
4 Only a small part

Año	From the production stored, how many months did it take to the family consumption in the year?	Did you buy this type grain to feed your family? 1. Yes 2. No	For how many months did you buy?	If you had to buy, with what money did you buy in the year 2009? 1 Money obtained from the farm 2 Money gotten from work out of fa 3 Remittance 4 Loaning 5 Another	Why did you have to buy this grain? 1 Bad harvest 2 Limited storage capacity 3 They sold all the harvest because of an emergency 4 Limited land for sowing 5 Limited sowing 6 Other
2009					
2008					
5 years ago					
Before acquire the silo					

4. Evolution of the conditions living

1. How do you consider that changed the living conditions of your family in the last 5 years ago in the following aspects?:			
Aspects:	How do you feel currently: *1. Much better* *2. Better* *3. The same* *4. Worse* *5. Much worse* *6. Does not know*	What is the reason of the change *1. There is a better sell of the production of grains* *2. There is a great production in the farm because you harvest m grains* *3. There is less lose of grain harvest* *4. There is a better production in the farm in general* *5. The work out of the farm has improved* *6. Another*	*Explications:*
1. Food for the family			
2. Health			
3. Housing conditions			
4. Education of the children			
5. Family employment			
6. Family income			
7. Farm production			
8. Woman's work load			
9. Being taken into account more by the community			

Lastly, according to your opinion, what has been the most important change in your life since you get the metallic silos?

THANK YOU VERY MUCH!

B) Tinsmiths

INTERCOOPERATION
NITLAPAN-UCA
ETH

Survey number [ ]

QUESTIONNARIE OF TINSMITHS

5-YEAR EX-POST POSCOSECHA PROGRAM

IMPACT STUDY CENTRAL AMERICA 2004-2009

Respondent name:
1.____2.______________________________________

Country: __________________

Department: ____________________________

Municipality: ________________________________

Community: ________________________________

Ethnic group:______________

Interviewer name: ____

Supervisor name: ____

Filling date: ______/_______/______

Estimated time filling questionnaire (hrs)_________

I. FAMIILY CHARACTERISTICS

Respondents characteristics (all those involved in the tinsmith activity)

1. How many people in the family living in this household? (They eat the same pot) :_______

2. How many family members are in this business? _______

Name Place name and surname of people over 12 years	Position in household	Sex	Age present	Education level	Is it the tinsmith main activity?	Another activity that you do?	Since when is dedicated to the activity (start year)?
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
	1. Head (a) home 2. Spouse (a) 3. Son or daughter 4. Other relative (specify)________	1.M 2. F	*Years old*	1. None 2. Primary 3. Secondary 4. Technical 5. Professional Other (specify)	1. Yes 2. No	1. Agriculture (farm) 2. business 3. wage labor 4 . housework 5. Only study Other_____	

3. How many children aged 7 to 12 years living at home?: _______

4. How many go to school? Child (male)________ Child (female)________

5. How many children under age 7 living in the home:_______ boys <7 years. _______ Girls <7 years___.

II. FAMILY INVOLVEMENT IN THE BUSINESS SILOS

1. Family members involved in the business	2. Function they perform: 1. Purchase and transport of materials 2. Galvanized sheet metal cutting 3. Sales 4. Administration and decision making 5. other: specify:		3.Business type: 1. Completely family 2. Family business with employees 3. Individual with employees 4. Other (specify)		3.
	2004	**2009**	**2004**	**2009**	
1.Husban					
2.Wife					
3.Sons					
4. Daughters					
5. Father/ mother					
6. Grandfather/ mother					
7. Brother					
8.Grandson/ daughter					
9. Son-daughter in law					
10. Other relative (specify)					

III. PARTICIPATION IN ORGANIZATION

Any family member participates in an organization

1. No: continue with next question
2. Yes: (list all the organizations involved in the family)

Who participates? (key 1)	Name of Organization / Project	What type of organization? (key 2)	Years of being organized	Role it plays in the organization (key 3)	What kind of support or assistance received from the organization?

Key 1
1. Head
2. husband/wife
3. Son/daughter
4. Other relative (specify)

Key 3
1. affiliate member
2. President
3. directors member
4. Other (specify)

Key 2
1. Guild (craft)
2. Agricultural cooperative
3.Other (specify)

Key 4
1. Financing
2. training and Technical Assistance
3. Marketing support.
4. Other (specify)

IV. SILOS PRODUCTION (PERIOD 2004-2009)

Funding silos production in recent years			**Technological level**
In the last five years has requested a formal loan to finance your activity?	Do you received the loan requested?	How you invest the loan?	How to evaluate the technique of manufacture of silos now?
1. yes 2.No	1. yes 2.No	1. Machinery and equipment acquisition 2. Construction of new building for production 3. Improvement of production infrastructure 4. Purchase of materials 5. Other (specify):_______	1. The technology is outdated and no longer meets the standards of operation 2. Technology requires significant changes and investment 3. The technologies are at a good level, and only require minor changes 4. Technology is good and only need to replace worn equipment and tools in the following five years.

2. Silo production mode in recent years (more than one option)	**3. Training received for the production and marketing of silos since starting the business?**
How to manufacture the silos? 1. According individual request 2. Upon request channeled through cooperative or association 3. Advance (in stock for sale) 4. Other (specify)	1. Fabsil I (manufacture of silos 2. Fabsil II (construction of silos 3. Tins Work 4. Administration I 5. Administration II 6. All of the above (specify)

4. Main difficulties in the silos production

1. What are the three main problems facing in the development of silos?	2. How has tried to solve these problems?	3. What are you doing to improve the situation of your business? (Can answer more than one option)
> in order of priority. Key 1: 1. Lack of material on the market 2. Quality of material 3. Lack of infrastructure (local 4. Financing 5. The price of material 6. Lack of workers 7. Other._______________	(As key 1) 1. Support to NGOs / State 2. Tinsmiths Support Organization 3. Changing marketing firm that sells materials 4. It has not solved 5. Applying for credit 6.Other :______	 1. [] New Innovative Designs 2. [] Purchase or extension of Local 3. [] Buy new tools 4. [] Find new customers 5 [] Has not yet thought 6. [] Others, Specify
1		
2		
3		

5. The last years, in addition to silos, you have fabricated other metal products??

1. Yes _ (fill box) 2.No ___ *(If no, proceed to the next question)*

What kind of metal products (design) last year? Key 1	Quantity produced	Size (Measure) 1. Liters 2. Kilograms 3. Ounce 4. Arroba (@) 5. Other (specify)	Sale price Unit C $	Since when is making this type products? (years)	*Key 1*
					1. Showers
					2. Rope pump
					3.Buckets
					4. Funnels
					5. Bird feeders
					6. Bird feeders
					7. Dishwasher
					8. Casserole
					9. Cake pans
					10. Mugs
					11. Balance Cup
					12. Grain bucket
					13. Garbage collector
					14. Candlestick
					15.Oil lamp
					18. Chandelier
					19. Canal water to drop
					20. Other (especificar_________)

V. SILOS SALES

1. Record production

Account for sales silo per year from 2004 to date (2009). Based on historical records or its historical memory.

Size silo	2009	2008	5 years ago (2004)
4 qq			
8 qq			
12 qq			
18 qq			
30 qq			
Other: __ qq			

2. Selling price and production costs of silos

What was the average price of a silo of 18 quintals and each components of the cost?

	2009	2008	Hace 5 años (2004)
Price 18 qq silo			
Unit cost post-harvest lamina			
Unit cost lb tin			
Cost of wages activity			

3. **Customers, sales and payment mode**

Sale of products	Who sold? 1. Individual production 2. Wholesale Intermediary 3. Retail Broker 4. ONG`s 5. Financial Micro 6. Business formal 7. State Institution 8. Others	Indicate name (s) if possible	Sales of these products are made: 1. Individual 2. Collective 3.By Organization 4. Other, Specify:	Method of Payment 1.Funded 2.Cash 3.Monthly premium payments 4.Other (specify)
Most of the silos	2004: 2009:			
The lower part of the silos	2004: 2009:			
Other tins metal products	2004: 2009:			

4. If you compare the number of customers in silos in 2004 (5 years) and 2009, there has been any change?
   1. They are almost the same customers
   2. Have increased
   3. Decreased

   (In this case, explain: ____)

5. What do you do to increase the sale of silos / find new customers?

____

____

6. **Main difficulties in marketing silos**

1. What are the main problems facing the marketing of the silos? Put in order of priority. 1. Lack of customers 2. Non-payment of customers 3. Large fluctuations in orders 4. Product Returns 5. Customer complaints 6. Other :___________	1. How do you think you can solve these problems? Note: No impact on response 1. Support institutions 2. Tinsmiths Support Organization 3. Other :___________

VI. IMPACT

1. **Wage employment**

Year	1. How many permanent employees in the business is the production of silos/tins work?		2. How many part-time employees in the business of the production silo/ tins work?		3.Explanation in the lower or increase in the number of employees
	H	M	H	M	
2009					
5 years ago (2004)					

Year	4. What is the monthly cost of a permanent employee in the business of producing silos / tins work? (C $)		5. What is the daily cost part-time employee (wages) in the business of producing silos / tins work? (C $)	
	H	M	H	M
2009				
5 years ago (2004)				

2. Income

1. What has been the annual gross income of the family coming from the sale of silos and tins work products? U$			
Year:	Income from sale of silos 1. Less than US$ 500 2. From 500 to 1000 US $ 3. From 1,000 to 2,500 US $ 4. Over US $2,500	Income from sales of tin products 1. Less than US$ 500 2. From 500 to 1000 US $ 3. From 1,000 to 2,500 US $ 4. Over US $2,500	Where did the source of most of the household income 1. From farm 2. Tinsmith business 3. sale of labor 4. Business 5. Selling other services 6. Other (especifique_____)
2009			
5 years ago (2004)			

3. Using income (family household expenses and investment)

In the last five years has made some investment from the business of the silos? 1: Yes____2: No______			
Type of investment (Key 1)	Year of investment	Approximate amount (U $)	Who decided the investment? (Key 2)

Key 1

1 In the traditional business silos
2 On improvements to housing.
3 On the farm (Agricultural Prod.)
4 In the education of children
5 In a commercial activity.

6 Other (specify).

4. Food security

Year	Number of months per year, mostly family food from the same that produces (in case of farm)	Number of months per year the family has to buy most food with money from the tins work business.	Number of months per year the family buys most of the food with other money.
2009			
5 years ago (2004)			

5. Changes in living conditions

HOW HAS CHANGED YOUR CONDITION OF LIFE IN RELATION TO FIVE YEARS AGO IN THE FOLLOWING ISSUES?		
Issues:	How do you assess your current situation *in relation to five years ago?* 1. Much better 2. Best 3. Same 4. Worse 5. Much worse 6. not response	**Explanation**
1. Food for the family		
2. Health of the family		
3. Condition of the house		
4. Education of the children		
5. Family employment		
6. Family income		
7. Production on the farm		
8. Work load of the woman		
9. Being taken into account more in the community		

THANK YOU!

Annex 8: Report expert interviews
(Note: support document, not to be distributed independently of impact study report)

POSTCOSECHA 5 YEAR EX-POST IMPACT STUDY

Expert Interviews Report

Information and preliminary analysis from interviews

Robert Berlin & Martin Fischler
Intercooperation

Bern, May 2010

Contents

1. Background and methodology

The expert interviews were conducted with the aim to complement the findings from the survey (silo users/non-users and tinsmith). They were carried out in a two-stage approach. The first stage consisted of interviews conducted with key informants for analysis of the dissemination and transfer of technology model in the four countries, and obtained information on agricultural policies and food security at country level. This information was used to identify critical factors concerning the business model, management structure and the agricultural context. The second stage consisted of experts interviews at a regional and international level. The expert interviews were guided by the research hypotheses formulated in the inception report and semi-structured questionnaire was used designed according to these hypotheses. In this expert interview report, the hypotheses will be discussed.

Special acknowledgements go to René Galdámez for the excellent support given by accompanying the interviews in Nicaragua and Honduras (with Robert Berlin), and in El Salvador and Guatemala (with Martin Fischler) and contributing substantially to the discussion of the findings. Our thanks also go to all the interviewed persons who have taken the time to answer our questions and discuss findings (see list of interviewed person in Annex).

1.1 Postharvest specialists and institutional informants (dissemination)

30 Postharvest experts – that have been directly been involved with the project- from Nicaragua, Honduras, Guatemala and El Salvador were selected for this study. These interviews provided insights to understand the key success factors and limitations of the impact model in the context of Central America (and a few replication experiences conducted elsewhere), and the implication for further dissemination of the Postcosecha approach. The 30 postharvest experts consisted of person from institutions/ consultants, representatives of cooperatives and from distribution channels (NGOs and Projects).

The study at Postharvest level has analyzed the critical elements/ factors of the impact model: technology, production & dissemination chain, Business model based on market mechanisms and public-private partnership, and management structure.

The quality control system in place in each country as key elements of success of the business model has been analyzed in-depth. Special attention has been given to the case of Guatemala where the programme has been relatively more successful after the support from SDC ended.

Table 1: Survey sample by type of experts and country.

Respondents in sample	Guatemala	El Salvador	Nicaragua	Honduras	International	Total
Postharvest experts	3	3	1	3	4	14
Tinsmith cooperatives	1	2	2	1		6
Distribution channel	2	2	3	3		10
Total Postharvest experts	**6**	**7**	**6**	**7**		**30**

1.2 General experts on agriculture policies, food security

The general experts on agricultural policies, food security consisted on 11 experts from Nicaragua, Honduras, Guatemala and El Salvador including some regional and international experts. They provided the research team information about the past and current situation of grain production in Central America, trends, potentials, and public policies concerning grain production and food security. Additionally, general experts at regional and international level have been included in this study.

Table 2: Survey sample of general experts and country

Respondents in sample	Guatemala	El Salvador	Nicaragua	Honduras	Total
Experts in Food Security and agriculture policy :	**3**	**4**	**3**	**1**	**11**

2. Study hypotheses

The research team developed a series of hypothesis to be verified during the interviews, both at the level of Postharvest experts and at the level of general experts. These are presented here in detail.

2.1 Impact hypothesis at the level of the Postcosecha programme

Hypothesis 1: Key success factors of the Postcosecha programme are: 1) technology, production and dissemination chain

This part analyses success factors and limitations related to the technology, production and dissemination chain during and after the project life. Its starts from the hypothesis, that the success of Postcosecha is mainly due to the quality excellence of silos and to an efficient dissemination chain. However, because postharvest experts have been involved with the programme at different level, they all have been asked to identify key success factors and limitations, and how these problems and limitations evolved after the end of the project. Frequency of responses for each factor has been calculated and analyzes to determine common trends and differences at country level.

Hypothesis 2: Business model based on market- mechanisms, public-private partnership and a clear exit strategy has been the base for sustainability

This hypothesis has been tested looking at how services and activities have been undertaken after project's end, and who is finally paying. Sustainability is defined both with the final benefits and with the means through which the benefits are achieved. However, in the context of food security, sustainability often request public sector to take responsibility into their objectives and planning. Frequency of response for each service provided has been calculated and then discussed.

Hypothesis 3: Management structure has been institutionalized in local structures at the project's end

Despite the difficulty to calculate the transactional costs during the lifespan of the project, some basic aspects concerning the type of Project management structure have been assessed. Discussions with experts have tried to capture the issues, challenges, things to do, and thing not to do from the perspective of a replication concerning the business model.

2.2 Impact hypothesis at the level of food security and agriculture policies

Hypothesis 4: Policies, trends and barriers in relation to food security and the production of staple grains have significantly influenced the programme
The analysis of national statistics shows that there are important differences between countries, in particular regarding productivity, prices and import/export of staple grains. This survey tries to capture reasons of differences and how they affect positively or negatively the programme.

Hypothesis 5: Postharvest and metal silo have contributed to increase food security
The study analyses from an expert point of view, how the programme has contributed to increase food security.

Hypothesis 6: Recent trends have been in favour or in contra of silo adoption
The study analysis whether general experts perceive that current trends are positive or negative concerning silo diffusion.

Hypothesis 7: Lessons learnt from the Central America Experience are useful for replication
General experts have been asked for recommendations concerning a possible replication of the programme in new country.

3. Evolution of Postcosecha approach after project's end

3.1 Key success factors and limitations of the Programme

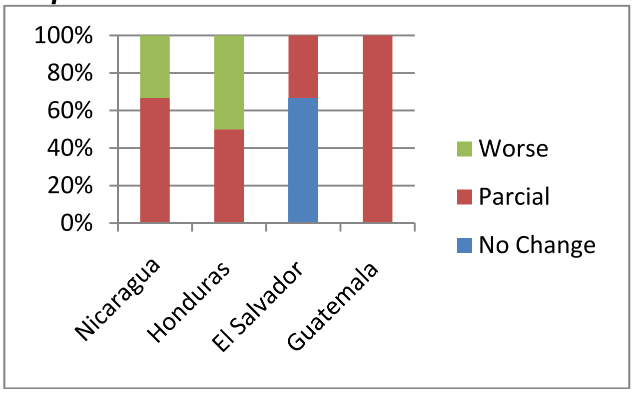
Table 3 identifies the main success factors identified by respondents in the sample. It shows that the three factors mentioned more frequently by postharvest experts as key success factors have been: inter institutional alliances, appropriate technology, followed by training of tinsmiths. The Programme has created a favourable climate to work with different actors of NGO and Governments. This however has not always been a harmonious process. Governments attempt to take over the programme for political reasons, leading sometimes to frictions. Besides these 3 main success factors, other 9 success factors have been mentioned like access to finance, low cost of the technology, monitoring and quality control.

Table 3: Main success factors mentioned by the respondents

		Frequency of response	Total Percent
1	Inter institutional alliances	21	18%
2	Appropriate high quality technology	17	15%
3	Training of tinsmith	15	13%
4	Access to finance for tinsmith	10	9%
5	Low cost of the technology	9	8%
6	Monitoring and quality control	8	7%
7	Training to silo users	8	7%
8	Promotion through TV and Radio	8	7%
9	Business orientation	8	7%
10	Long term strategy	4	4%
11	Tinsmith networking	3	3%
12	Linkages with factory (zinc)sheets	3	3%
	Total	**114**	**100%**

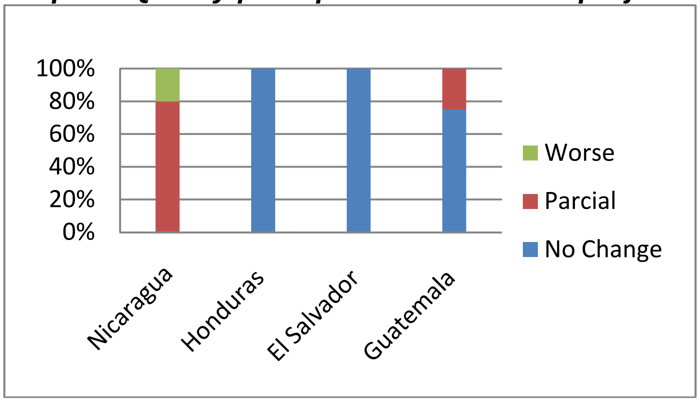
Referring to inter institutional alliances, postharvest, experts from Nicaragua and Honduras are reporting that the situation is worse and could partially be maintained. Only in El Salvador the inter-institutional dynamic continued significantly after the project's end.

Graph 1: Evolution of inter-institutional alliances after project's end



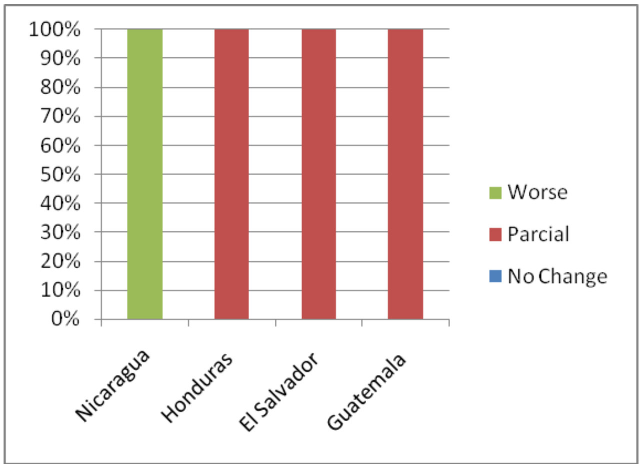
As to the question of high quality appropriate technology, only in Nicaragua, where direct involvement of public entities has been lower during the last 10 years, experts perceived that quality of silos gradually decreased after project's end.

Graph 2: Quality perception of silos after project's end



Concerning the training of tinsmiths, as a third success factor, respondents have mentionned that in Honduras, El Salvador and Guatemala the situation could partially be mantained. Unsurprisenly, for Nicaragua, where training of tinsmiths have been discontinued after project's end, the situation is perceived to be worse today

Graph 3: Training of tinsmith after project's end



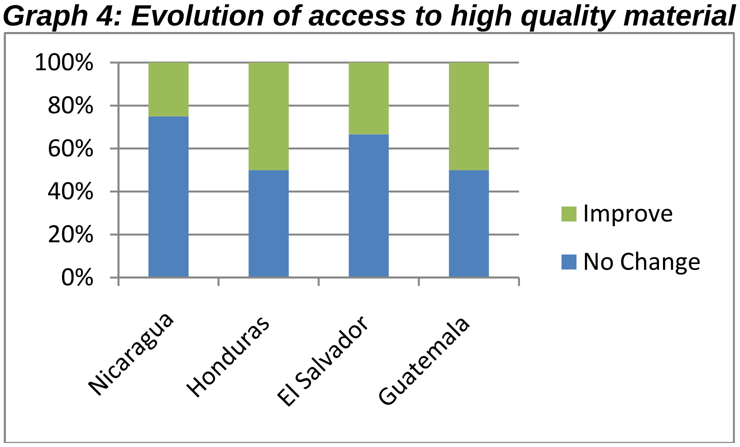
The survey also reveals a list of 15 different problems and limitations identified during the project's life, from which 3 can be considered as **main problems and factors of limitations**: 1) difficult access to galvanize sheets and quality material, 2) high cost of material to build silos, and, finally 3) difficulties in transport and lack of tinsmith in remote areas. Nevertheless, it has to be mentioned that the last problem related to difficult access to silos has not been mentioned in Guatemala.

Table 4: Main problems and limitations during the Project

		TOTAL	Total Percent
1	Difficult access to galvanize sheets and quality materials	**11**	**20%**
2	High cost of materials	**9**	**16%**
3	Difficult access to silos (e.g. transport)	**8**	**15%**
4	Low agricultural production (drought)	**4**	**7%**
5	Change in Governments	**3**	**5%**
6	Quality control and Monitoring	**3**	**5%**
7	Weak tinsmith associations	**3**	**5%**
8	To rapid Exit of SDC	**2**	**4%**
9	Donations and subventions	**2**	**4%**
10	Poor awareness	**2**	**4%**
11	Tinsmith with no business orientation	**2**	**4%**
12	Poor silo and postharvest handling	**2**	**4%**
13	Access to Phostoxine	**2**	**4%**
14	High cost of transference	**1**	**2%**
15	Finance to tinsmith	**1**	**2%**
	Total	**55**	**100%**

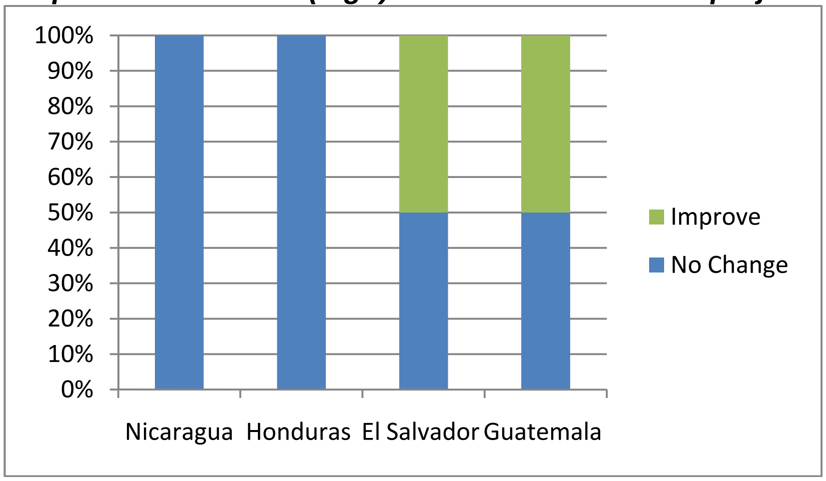
Referring to difficult access to galvanize sheets and materials, survey of respondents shows that the situation has sensibly improved. However, in Nicaragua and El Salvador the majority of respondents still perceive that access to high quality material remains an important problem.

Graph 4: Evolution of access to high quality material after project's end



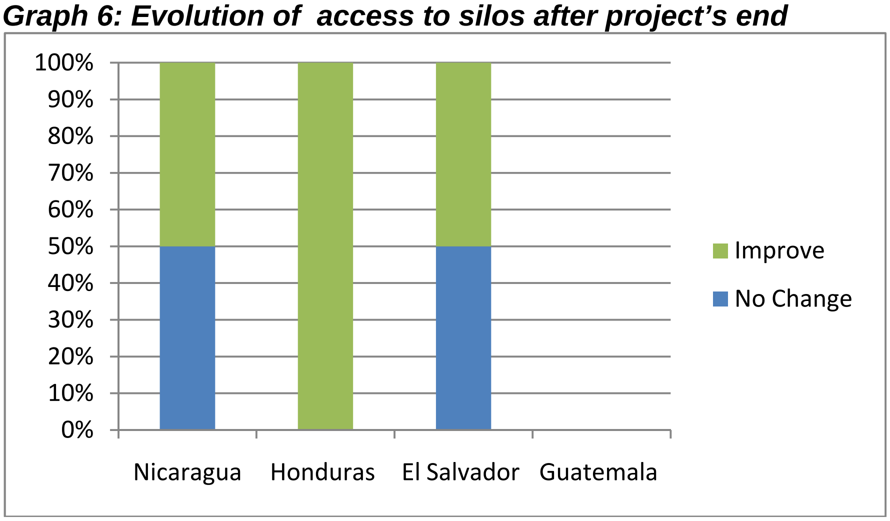
From those who mentioned the high cost of materials as being an important problem and limitation for the silo diffusion, only respondents from El Salvador and Guatemala perceive that the situation has been improved. For Nicaragua and Honduras, high costs of material remain an important problem.

Graph 5: Evolution of (high) cost of materials after project's end



Finally, survey concerning access to silo shows important country differences. In Nicaragua and El Salvador, around 50% of the respondents considers than access to silo is still a significant problem. On the other side, 100% of respondents in Honduras consider than access to silos has improved since project's end. In Guatemala, this issue has never be mentionned as a problem.

Graph 6: Evolution of access to silos after project's end

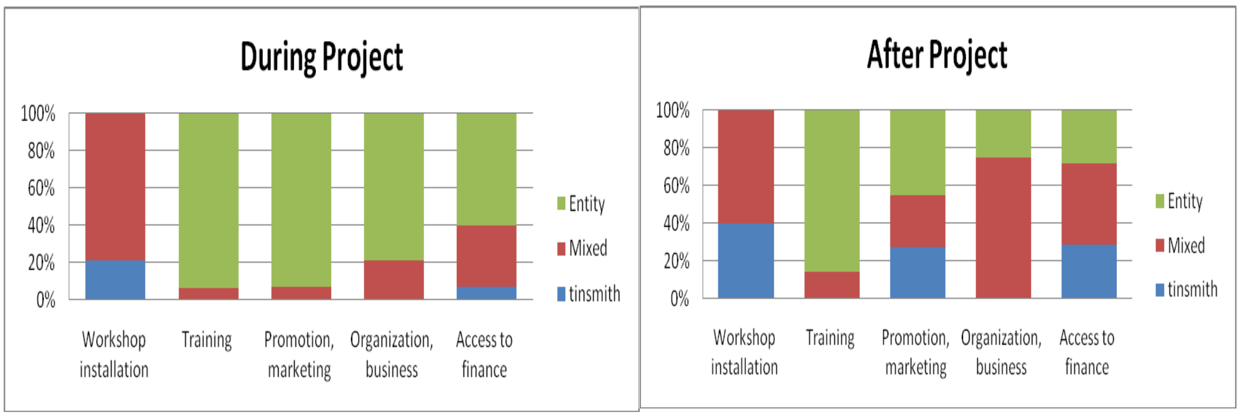


3.2 Sustainability of Postcosecha's business model

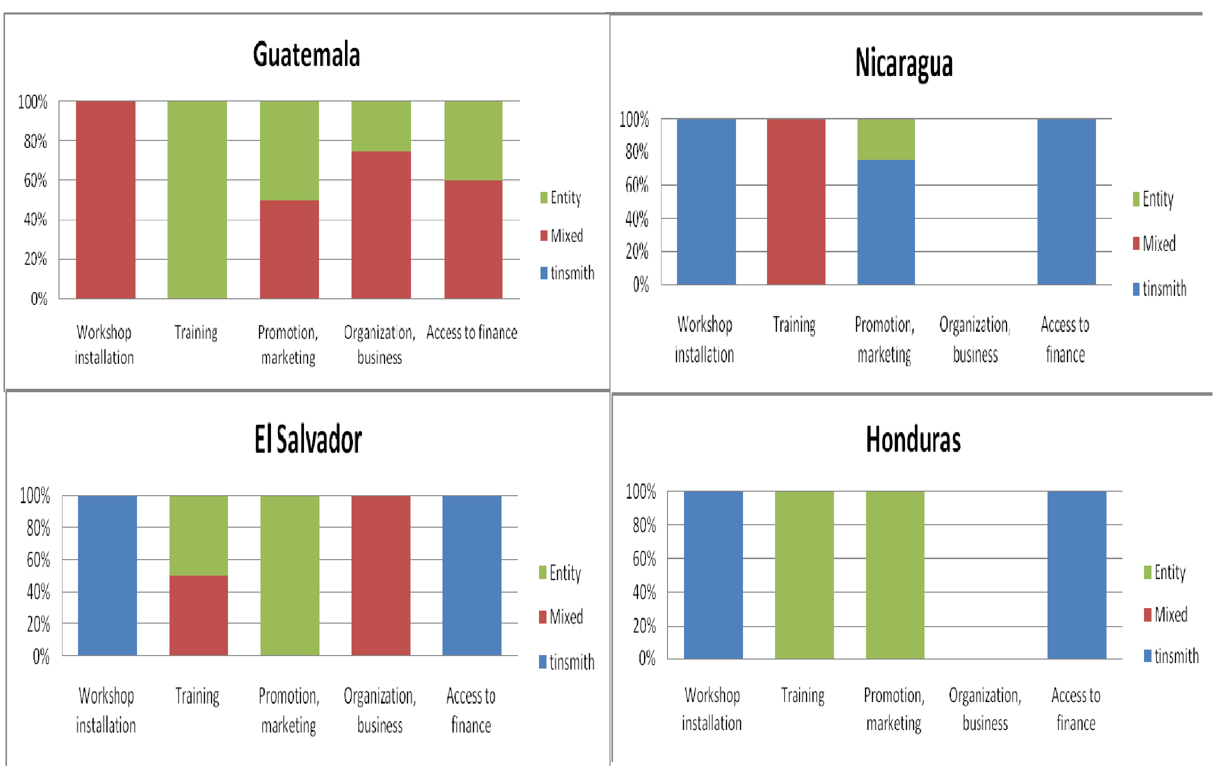
Hypothesis 2 of the survey states than the base for sustainability of Postcosecha has been a Business Model based on **market-mechanisms**, **public-private partnership** and a **clear exit strategy**.

This hypothesis has been tested looking at how services and activities have been undertaken after project's end, and who is the end payer. Sustainability is defined both with the final benefits and with the means through which the benefits are achieved. However, in the context of food security, sustainability often request public sector to take responsibility into their objectives and planning. Frequency of response for each service provided has been calculated and is presented in Graph 7 and 8.

Graph 7: Funding sources for services to tinsmith during and after the project



Graph 8: Funding sources for services to tinsmith after the project per country



The Postcosecha intervention model aims at anchoring production and dissemination of the technology in existing institutions and market mechanisms. It includes the four elements (business functions) as discussed by experts:

Workshop installation. According to experts, only in Guatemala, tinsmith continues to receive some support for the installation of a silo workshop.

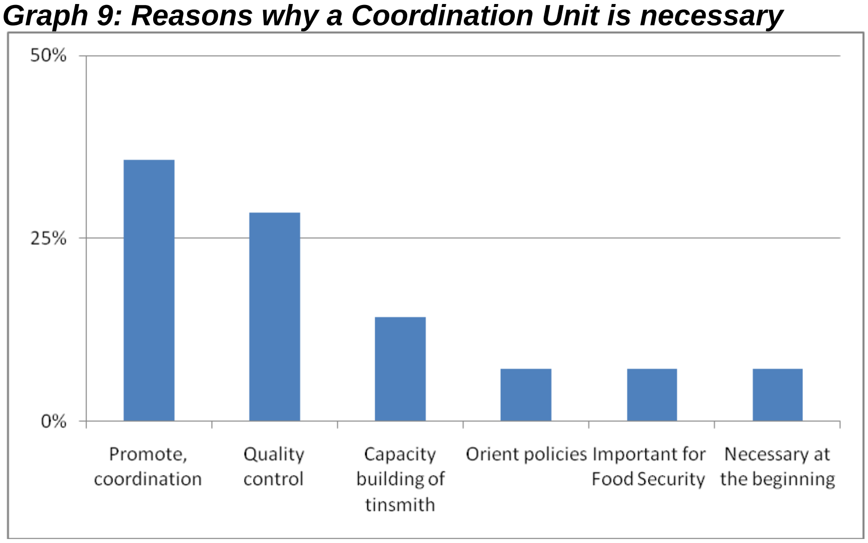
1. **Training and capacity building experts**. With the exception of Nicaragua, training activities (production, entrepreneurship, postharvest storage, etc.) were maintained although not at the same scale.
2. **Promotion and marketing.** Marketing and promotion is still very much drive by private and public entities. Only in Nicaragua, public support in promotion and marketing.
3. **Organization and business support.** Only in Guatemala and El Salvador, entities continue to provide support in organization and business management even if at a lower scale.
4. **Access to finance**: With the exception of Guatemala, no support is provided to tinsmith to facilitate access to finance according to experts interviewed.

3.3 Strategic focus on institutionalization and replication

Hypothesis 3 stating that management structure of Postcosecha has been institutionalized at the project's end, aimed at analyzing which functions of the Postcosecha Unit are necessary - and to what extent – they have been institutionalized.

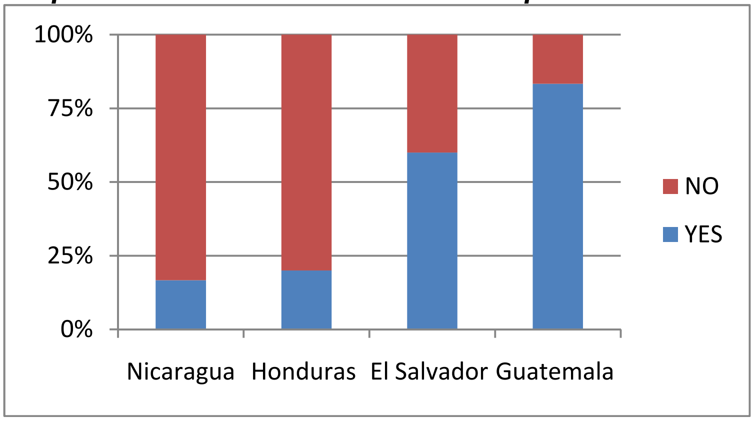
Necessity of Coordination Unit - Nearly everyone believes that a Coordination Unit is necessary to make the business model viable, only two believes that it is only necessary at the beginning. The three most important reasons (functions) mentioned have been: 1) promotion and coordination, 2) quality control, and 3) Capacity building to tinsmith.

Graph 9: Reasons why a Coordination Unit is necessary



The survey also aimed at assessing whether – and to what extent –functions have been maintained in each country.

Graph 10: Does Postcosecha Unit respond to current necessities



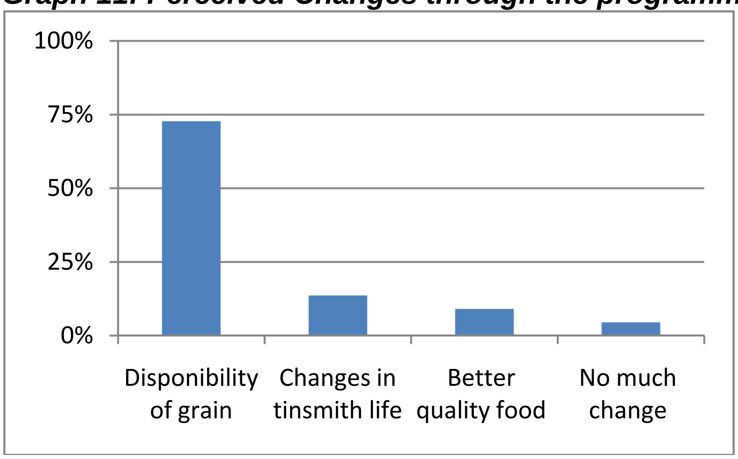
Results of the surveys show important differences for each country:

- In Nicaragua, the situation is the most precarious, only limited functions in promotion have been maintained in INTA
- In Honduras, only one function (capacity building) has been maintained through INFOP
- In El Salvador and in Guatemala, the Postcosecha Unit is stronger and could maintained leadership in Postcosecha, as for example inter institutional networking.

3.4 Perceived changes due to the programme

According to the experts interviewed, availability of grain has been the most relevant change directly due to Postcosecha. Other less important variations mentioned have been improvements in tinsmith life, better quality food. Only one expert felt that not much change can be directly attributed to Postcosecha.

Graph 11: Perceived Changes through the programme



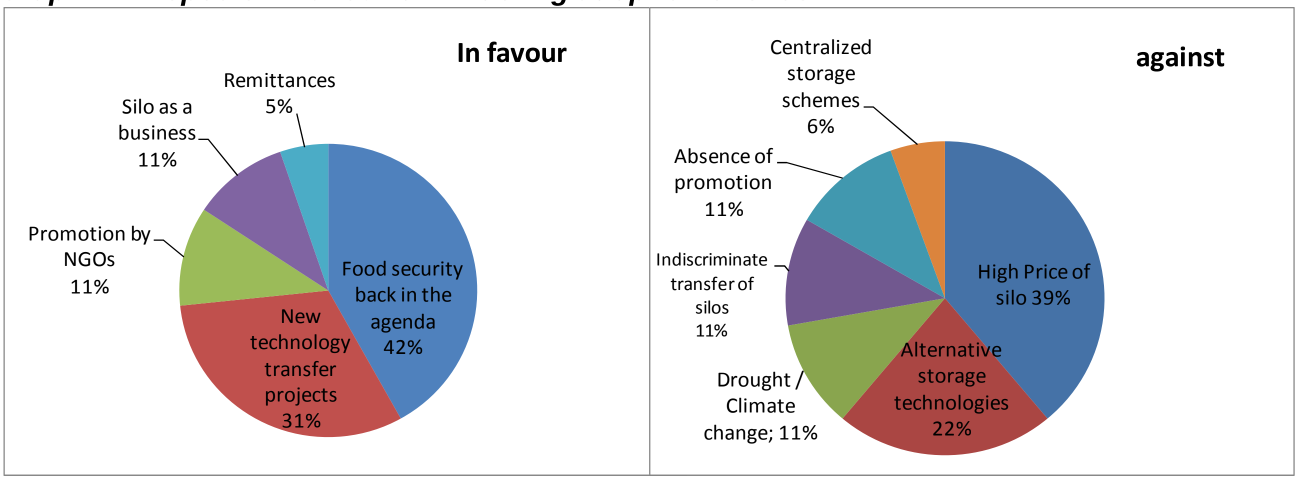
What has been the most important contribution of Postcosecha for Food Security?

Gustavo Sain y Jorge Ardila: The metal silo contributed to Food Security of small producers through the reduction of losses in postharvest, and becoming a regulatory mechanism for food supply and self consumption.

3.5 Important aspects influencing Postcosecha's business model

Besides, post-harvest expert's identified some "external" import aspects that influenced positively or negatively adoption of silos.

Graph 12: Aspects in favour or hindering adoption of silos



- ✓ **In favour:** agriculture and food security is re-gaining importance in Central America due to the increased vulnerability of the rural population; new projects based in technology transfer and markets of technologies have been supported during the recent years and many NGOs keep promoting metal silos; metal silos are increasingly seen as a business opportunity (not only for farmer); access to remittances increase the capacity to purchase the silos.
- ✓ **Against:** Increase in price of silo (increased metal price), replacement by cheaper storage technologies (e.g. grain storage bag), increase in drought / climatic variability affecting production and indiscrimination distribution of silos are hindering factors for further adoption of the metal silo.

3.6 Implications for replications of Postcosecha's business model

Finally, from the surveys with postharvest experts some recommendations about what ***to do*** and what ***not to do*** have been highlighted.

Table 5: To Do and Not to do for replication

	Recommendations	**%**
To Do	Context analysis Broader view (not only technical)	27%
	Emphasis in capacity building	26%
	Inter institutional agreements	18%
	Monitoring and quality control	15%
	Reduce silo Price	9%
	Proof of concept	3%
	Focus on associations	3%
Total		**100%**
Not to do	Distribute silos accomplishing targets only (No. of silos!)	24%
	Create dependency from tinsmith	18%
	Concentrate only on tinsmith	12%
	Politicize	12%
	Short term Projects	12%
	Use costly material	12%
	Not defining exit strategy	6%
	1:1 replication (blue-print does not work)	6%
Total		**100%**

What are the key steps for replication?
Kurt Schneider:

1. Promotion/ training of producers (didactic and promotional material)
2. Training of tinsmith
3. Quality control of silos
4. Access for to finance for tinsmiths and producers
5. Strategic alliances with Ngo and Government
6. Availability of materials
7. Organization of tinsmith
   - ➔ Necessity of coordination unit
   - ➔ Long term involvement

4. Impact at the level of food security and agricultural policies

The analysis of national statistics shows that there are important differences between countries, in particular regarding productivity, prices and import/export of staple grains. This survey tries to capture reasons of differences and how they affect positively or negatively the programme.

4.1 Policies, trends and barriers that have influenced the programme

In general, experts perceive that national policies have improved in regard to food security issues. It is interesting to see that no experts think that the situation regarding public policies were better before than today.

Table 6: Policy in regards to food security

		Past 20 years	Today
1	Policies favouring food security	0	5
2	Policies disfavouring food security	7	1
3	Ambivalent, no clear indication	3	4
	Total	**10**	**10**

In **Nicaragua,** after the restructuration of the State that took place in the 90s, we observed a large dispersion of institution sometimes competing between them for funds (INTA, IDR). At that time there was a general lack of prevention. Today, according to **Arcangel Abaunza** (MAGFOR) there is a better coordination of actions thanks to PRORURAL and a concept of Food Security sovereignty has been created.
For **Ali Jimenez** (FAO) the Sandinista period was mainly characterized with instability due to the war and hyperinflation. The centralized production and commercialization system that was in place during this period has been abandoned during the Liberal Governments which in addition stopped financing production. However, mainly due to the microfinance institutions, we assisted in an increase of productivity, and the country even started to export beans. Besides this aspect, an important factor of increase of production has been expansion of area of agricultural land due to important changes in the "Frontera Agricola" **Eduardo Baumeister** (investigator).

In **Honduras,** the Principal focus of the Secretaría of Agriculture was on middle and large producers. The agriculture in hills has only been recognized recently as important for the country. In 1992 The "Ley de modernización agropuecuaria" introduced privatization of services. Nevertheless, staple grains were mainly supported by Aid agencies as a result of the dismantlement of state extension systems. Governments were traditionally focalized attention on agro export in low land and not supporting staple grain. Consequently, according to **Luis Alvarez Velchez** (FAO), there is a dramatic Lack of public support for germplasm conservation and GMO is imported.

In **El Salvador** the topic of food security was dealt with in an ambivalent manner during the last 20 years. Food security was mostly interpreted in a narrow sense restricted to production of maize and beans for home consumption. Today the government has adopted the globally accepted definition of F.S. (i.e. FAO) and is contemplated in one of the 10 programmes of the new government of president **Funes. K. Andrews/E. Cruz**

So far, **El Salvador** did not have a coherent policy or strategy in relation to food security. Most programmes were biased on giving free inputs to farmers (seeds, fertilizer etc.). For 2010 it is planned to hand out packages to 380'000 small farmers. The current government is recognizing more the

importance of F.S. and applying a wider concept, i.e. including aspects like nutrition, diversification of production (vegetable/fruit). Currently a consultation process is underway with NGO's, FAO, WFP, farmers associations etc. which should provide inputs for the formulation of a Law on Food Security. Postharvest will be one important aspect, FAO is currently conducting a large study on this topic (incl. exp. from Brazil) which should provide important insights to come up with an adequate storage strategy for the country (study not yet out). (**Hugo A. Flores**)
Neoliberal policies were in disfavour of small farmers producing basic grains. The dollarization had further negative effects for small farmers (higher production costs/interest rates etc.). About 5 years ago, the government through MAG started to distribute massively packages with seeds/inputs to small farmer to boost production of maize and beans. The current government is continuing this practice; in addition programmes for diversification (fruit/vegetables) are foreseen to reduce dependency on imports. (**Salvador Urrutia**)

In Guatemala, in general, the public sector has neglected the smallholders. Today the topic of food security has gained importance (61% of the rural population in Guatemala is under- or malnourished) (**Danilo Agostin Gonzalez Araúz**).
For **Carlos Anzueto**, there is a Lack of mechanism to cope with climate change and grain storage as one pillar of resilience. In addition, lack of mechanism to stabilize prices lead to decentralized grain storage, and metal silo is an ideal approach.

Trends in production of staple grains

From the interviews, no differences in increase of production can be observed from the last 10 years to more recent and future trends. In summary, it seems that the production will continue to increase as it did for the last 10 years.

Table 7: Trends in production of staple grains (maize, beans, and rice)

	Past 10 years	Recent/Future trend
1 Production increased	5	6
2 Production decreased	2	1
3 Production maintained	3	4
4 No clear indication	2	1
Total	**12**	**12**

In **Nicaragua,** according to **Arcangel Abaunza** (MAGFOR) **and Eduardo Baumeister** (investigator), production of staple grain increase more because of new areas (frontera Agricola Pacific, Central Atlantic) than for productivity. Stagnation of Yields due to subsistence agriculture can be observed. However, for **Ali Jimenez** (FAO) the country has an important potential in increasing productivity through irrigation which is largely underutilized for small farmers. Production still concentrates in subsistence farming.

In Honduras, Maize production is remaining at the same level. Periodically, there is a deficit in beans in certain period of the year and the country imports grains form the region **(Luis Alvarez Velchez,** FAO).

El Salvador, Production has increased (mainly maize), El Salvador has highest productivity in C.A. because of use of improved varieties and inputs. However, the county is dependent on imports (quotes CAFTA). The problem is that past official figures on production were inflated, they are not in line with data from the last census (2008), and current government is establishing corrected figures **(K. Andrews/E. Cruz).**

For **Hugo A. Flores**, the production level is maintained within the usual annual variations due to climatic factors. Through new programmes, the government hopes to increase annual maize and bean production by 4-5 and 1-2%, respectively. The projection is an increase from 19 million qq. to 25 million qq. to reduce imports from Nicaragua and Honduras, also USA. However, according to **Salvador Urrutia** the problem is that current figures are not reliable and likely overestimations. Productivity has increased but total production? 24 million qq. is certainly inflated. He rather estimates around 15 million qq. (maize). Beans: production has been maintained around 3.5 million qq Rice: Production has continuously decreased in the last 20 years due to competition with cheap imports.

For **Guatemala,** Maize and beans remain the pillars of food security. However, yellow maize is no longer produced in the country as there are cheaper imports from USA (**Danilo Agustin Gonzalez Araúz**). In general, production has decreased. Although some areas are planted with bio-fuels (cane, palms), Maize has potential in Petén, but there is problem to control grain humidity (problems of aflatoxins) (**Dr. Bresani**). Production especially of yellow maize has drastically reduced due to cheap imports from USA (**Carlos Anzueto**).

Barriers for small farmers to access markets for staple grains

Seven different barriers for small farmers to access markets can be determine from the interviews and are presented in table 8.

Table 8: Barriers for small farmers to access markets of basic staple grains (in order of importance)

	Barriers	**Frequency**
1	Non-tariff trade barriers	2
2	Imperfect markets	3
3	Not meeting quality standards	1
4	Lack of association	5
5	No commercial agriculture (more subsistence)	4
6	Poor efficiency in production	4
7	Access to finance	2
Total		**21**

Reasons given in Nicaragua:

- Dispersion of farmers; more subsistence agriculture; lack of association (**Arcangel Abaunza**, MAGFOR)
- Poor efficiency in production; no access to finance; new model of rural services; no extension service (**Ali Jimenez**, FAO)
- Extensive production patterns, low volume of production. Changes from staple grain to milk, coffee livestock (**Eduardo Baumeister**)

Reasons given in Honduras

- Dispersion of production, and weak association for commercialization (Luis Alvarez Velchez, FAO).

Reasons given in El Salvador

- CAFTA: Processing industry must buy a quota of national production in order to get import contingent (e.g. maize from USA). Some government programmes have established special treaty (convenios) to buy from farmers at negotiated prices and quality standards. New government has intention to increase direct buying from farmers for school and hospital nutrition programmes, also WFP (P4P). SDC has supported SICTA to strengthen associations (**Eduardo Cruz**)
- Governmental Programmes to buy from farmers (maize), farmers receive package of seeds/inputs (**Hugo Flores**).
- Building up of associations was only partly achieved. Programmes like FAO-PESA have increased buying from farmers. In the future, contracts between processing industry and farmers should become more important (ref. import quotas). (**Salvador Urrutia)**

Reasons given in Guatemala

- The mechanism for price stabilization has been lost (ref. INDECA). (Danilo **Agustín González Arauz).**
- Small farmers need incentives for increasing maize production to become more commercial farmer (get out of subsistence farming only). (**Carlos Anzueto).**

4.2 Importance of metal silo for food security and impact of the Programme

From the survey, important aspects and trends of the importance of Postcosecha, as a Postharvest technology Postharvest has been highlighted by general experts.

Table 9. Importance of Postharvest (incl. metal silo) for contribution to food security

	Import aspects & trends	**Frequency**
1	Substantial contribution to F.S. at national scale	6
2	Decentralized storage as strategic element of F.S.	5
3	Importance of stored grain in situations of disaster	5
4	Reduction of grain loss = substantial increase in income	3
5	More adapted for middle producers and traders	1
Total		**20**

Nicaragua
Importance for the concept of food sovereignty and security; Arcangel Abaunza. MAGFOR
Strong adoption rate; storage capacity has increase.; disaster risk reduction Ali Jimenez, FAO
Silo is well accepted ; relatively useful for small producers because of lack of production Eduardo Baumeister, Consultant
Honduras
Positive experience, reducing risks in Food Security ; reduction of losses from 28% to 5%; facilitate work for women; strong demand for silos continue Luis Alvarez Velchez, FAO
El Salvador
FAO: Postharvest loss of maize in El Salvador is 12-13%. Storage of grain in situation of disaster (Mitch, Earthquake 2001) is an important element to assure food security in these difficult situations and keep up "the moral of the affected population". Salvador Urrutia
Guatemala

Silo is widely used = contribution to national food security in a decentralized manner. Climate change, dry corridor, etc. gives more importance technology to increase storage capacity (i.e. metal silo). More recently, storage of grain in peri-urban areas in case of disasters like earthquakes has gained importance. Danilo Agostin Gonzalez Araúz

Table 10. Perception of the Impact of the programme in order of importance

	Impact	**Frequency**
1	Reduction of grain loss = increased food security	9
2	Installed decentralized capacity to produce silos	5
3	Increased incomes for farmers and tinsmiths	4
4	Stabilization of prices of grain (mainly maize)	4
5	Silo as a bank	2
6	Building up inter institutional alliances	1
7	Sustainability of activity beyond SDC	1
Total		**26**

Nicaragua
Food security at family level; has influence on Prices (regulatory role) Archangel Abaunza. MAGFOR
Reduction of losses, people have improve know how in post harvest (not only silo) Ali Jimenez, FAO
Useful monetary policy (silo as a bank). Eduardo Baumeister, Consultant
Honduras
Reduction of losses; from a food security perspective, reduce risk in the family Luis Alvarez Velchez, FAO
Guatemala
System of decentralized silo production allowed for massive transfer of silos on the country. Danilo Agustin Gonzalez Araúz
Programme Postcosecha has high social and economic benefits for the rural population, at low cost. Rural population is learning postharvest methods. Small subsidies are justified as they have big benefits, without being paternalist. Families are more food secure, healthier food. In addition creating rural employment (esp. tinsmiths). Carlos Anzueto

4.3 Recent trends that have been in favour or against silo adoption

To draw lessons learnt (Hypothesis 6) for a possible replication, the study initially looked at recent trends that are in favour or in disfavour of use of a metal silo in the Central American context.

Table 11: Trends in favour/disfavour for future use of metal silo?

	Trends favouring future use of silo	**Frequency**
1	Food security incl. postharvest in gaining importance	+++
2	Technology is simple, flexible (e.g. different sizes possible)	++
3	Stabilization of prices (i.e. maize)	+
4	Higher maize production through improved varieties	+
5	New markets (Venezuela)	+
6	Silo is well known	+
7	Trained tinsmiths = maintained capacity to produce silos	+
8	Personnel UCP capable and maintained	+
9	Favourable policies	+
	Trends disfavouring future use of silo	**Frequency**
1	Limited access to finance	++
2	Collateral effects of Phostoxin	++
3	Decrease in productivity due to climate change	++
4	Ideas of centralized grain storage (type IRA)	+
5	Substitution of maize/bean with high value crops	+
6	Lack of quality standards to allow communal storage	+
7	Presence of tinsmiths	+
8	High Prices of seeds	+

Nicaragua.
Food security remains very important Arcangel Abaunza. MAGFOR
New markets (Venezuela) foster production; cooperatives are becoming stronger; each farmer has storage capacity Ali Jimenez, FAO
Farmer families have their base in maize; increase necessity to increase productivity Eduardo Baumeister, Consultant
Honduras
Silo technology is well known; there are no mechanisms to access silo or to train tinsmith Luis Alvarez Velchez, FAO
El Salvador
Small farmers do not have to remain producing maize/beans in the hillsides for their survival. Maize/bean production should be boosted in zones where these crops are appropriate and do not cause land degradation problems. Small farmers should also go for high value crops (e.g. fruit) which are more apt in fragile zones esp. hillsides. K. Andrews
Communal storage: The metal silo technology would allow increasing storage capacity at communal level, could also be combined with Warehouse Receipt System. The bottleneck is the lack of quality standards which would allow to bulk maize for storage. Most farmers want to store their own maize. Salvador Urrutia

4.4 Lessons learnt from the Central America Experience useful for possible replications

General experts have been asked for recommendations concerning a possible replication of the programme in new country.

Table 12: Key Recommendations/lessons learned for replication of Postcosecha

	Recommendation	Frequency
1	**Emphasis on training of tinsmiths and org. of farmers (TA)**	**Very important**
2	**Start only if there is a longer-term vision + commitment**	**Important**
3	**Consideration of social-cultural aspects, not only technology** *Technology to elaborate silos; understanding the family economy; compare with other technologies; value chain vision Eduardo Baumeister, Nicaragua* *Programme is technology driven, social and cultural aspects are important aspects to consider when postharvest programme is starting. K. Andrews, El Salvador*	**Important**
4	**Concentrate programme in zone with high prod. Potential** **Honduras** Analysis of demand is important, together with advisory services to increase food security. Luis Alvarez Velchez, FAO, Honduras *Focus on zones with high potential for grain production, not going for common donor approach of "poverty alleviation". The technology will only partly work in such zones, and limited success will hinder further spreading of the technology. K. Andrews. El Salvador*	**Important**
5	**Take advantage of knowledge in C.A. and exchange**	**Important**
6	**Form inter institutional alliances (also public-private) from the start**	**Important**
7	**Place Programme in institutions which has understanding + commitment** Important to be embedded in the right institution from the beginning. Institution must understand the Programme and show a longer-term commitment. It does not have to be a public institution, can also be private or mixed. *K. Andrews. El Salvador*	**Important**
8	**Sufficient emphasis on communicating results**	**Important**
9	**Link with finance mechanism** *Effective technology: Convince producer to pay: link to a financial mechanism. Arcangel Abaunza, Nicaragua.*	**Important**
10	**Compare with other technologies** *Validation in regard to new post harvest technology: plastic technology (22qq) is more expensive Ali Jimenez, FAO, Nicaragua*	**Less important**
11	**Careful selection of tinsmiths + farmers**	**Less important**
12	**Transparency in fund management**	**Less important**
13	**Value chain / broad approach** *Silo is part of a whole technology package: production-postharvest-processing-marketing.... sufficient attention must be given to high quality technical support (extension). Salvador Urrutia, El Salvador*	**Less important**
14	**Useful to organize farmers**	**Less important**

5. Conclusion, validation and further development of Postcosecha intervention model

From the survey, the following can be draw up concerning validation and further development of Postcosecha intervention model.

5.1 Success factors and limitations of Postcosecha approach

Much attention has been given to develop a business model based on public private development partnership – particularly through efforts to institutionalize structures able to manage and finance support functions, and supporting tinsmith to upgrade their business, and farmers to purchase the silos. Expert's interviews indicate that main factors of success have been: inter-institutional alliances, quality technology, and training of tinsmith. On the other side, main problems and limitations encountered during the project life have been: access to galvanize sheets, high cost of material and access to silo (by the farmers).

Table 13. Main critical factors mentioned by experts (% of total responses)

	Frequency
Main success factors	
Inter-institutional alliances	**18%**
Quality of technology	**15%**
Training of tinsmith	**13%**
Main Problems and limitations	
Access to galvanized sheets	**20%**
High cost of materials	**16%**
Access to silos (e.g. transport)	**15%**

In order to better understand, strength and limits of the approach, the study looked at how these critical factors evolve until 2009 (five years without SDC's support). The critical factors can be grouped into three categories:

- Institutional coordination's focusing on public and private partnerships. Only El Salvador and Guatemala could maintain the dynamic initiated by the Programme. In Nicaragua and Honduras, inters institutional coordination gradually ceased after SDC's support.
- Issues related to quality technology. According to experts, Quality could be maintained in Honduras and El Salvador, partially in Guatemala, but not in Nicaragua.
- Training of tinsmith: Only in Nicaragua, training has stopped after sdc's support. IN the other three countries the programme could continue (even if partially).
- Issues related to the access of technology (including cost): In El Salvador and Guatemala, where significant efforts have been made in postharvest, cost is not anymore considered to be a problem. In Nicaragua and Honduras, cost access to materials is considered to be an important limitation.
- In relation to access to silo, the situation has improved in all countries.

Interestingly, important differences can be observed in the way that these factors evolved after the project's end showing differences in institutionalization. On one side, we have Nicaragua and Honduras where the model based on the three pillars: inter-institutional alliances, technology, and capacity building could only partially been sustained after SDC's exit. On the other side we have El Salvador and Guatemala, where governmental institutions have practically adopted and continued the full programme with own resources. These results help us to understand some risks and strengths of the Postcosecha approach. As expected, the relative success in Guatemala can be attributed to a higher level of institutionalization and to the fact that Postcosecha has been appropriate by the Government as a key strategy for Food Security. These results are consistent with earlier statements (evaluations reports). A Postcosecha programme positioned in Governmental entities heavily depended from public resources could suffer or benefit from changes in the politic agenda. On the other hand a programme positioned on the industry value chain (production, diffusion, services) would be able to catch up with new demand and tendencies.

5.2 Trend influencing further adoption / up scaling (or scaling out!)

Key trends influencing further adoption of silos include: First, Small scale agriculture and Food Security is re-gaining importance in the development agenda. Second, new projects based on technology transfer and markets of technologies have been supported during the recent years. Third, NGO in the different countries are promoting silos. Fourth, silos are increasingly been seen as a business opportunity. Fifth, remittances increase capacity to purchase silos.(*ref. Graph 12: Aspects in favour or hindering adoption of silos).*

In the assessment, experts perceive that the favourable context in regard to food security policies will increasingly be powered by public and private investment in technologies that helps small producers in increasing productivity and reduce vulnerability. On the other hand, alternative technologies may compete with metal silo (e.g., grain bag storage system) and replace it if more competitive in Price and quality.

BOX: Central America – policies in regard to food security and production of staple grains

In **Nicaragua,** during the restructuration of the State in the 90s, a large number of new public institutions were created and the Government stopped financing production. However, mainly due to the microfinance institutions, productivity increased, and the country even started to export beans. More recently we face stagnation of crop yields due to subsistence agriculture practices and quantity of staple grain increase more because of expansion of new areas (frontera Agricola Pacific, Central Atlantic) than because of increase in productivity. Concerning, interinstitutional coordination, progress can be mentioned mainly due to the creation of PRORURAL, and a new concept of Food Security sovereignty has been created.

In **Honduras,** the Principal focus was traditionally on middle and large producers. Public policies were concentrating in developing an agro industry in the low lands. The agriculture in hills, where staple grain production is concentrated has only been recognized recently as important for the country. In 1992 The “Ley de modernization agropuecuaria” introduced privatization of services. Nevertheless, staple grains were mainly supported by Aid agencies as a result of the dismantlement of state extension systems. In Honduras, Maize production is remaining at the same level. Periodically, there is a deficit in beans in certain period of the year and the country imports grains form the region. Concerning institutions, the country has been affected by the recent political turmoil and there is no clear policy or strategy in relation to food security so far.

El Salvador did not have a coherent policy or strategy in relation to food security so far. Most programmes were biased on giving free inputs to farmers (seeds, fertilizer etc.). The dollarization had further negative effects for small farmers (higher production costs/interest rates etc.). The Production has increased (mainly maize), and El Salvador has highest productivity in C.A. because of use of improved varieties and inputs. However, the county is still dependent on imports (quotes CAFTA). Currently a consultation process is underway with NGO's, FAO, WFP, farmers associations etc. which should provide inputs for the formulation of a Law on Food Security (i.e. including aspects like nutrition, diversification of production (vegetable/fruit). Postharvest will be one important aspect.

In Guatemala, in general, the public sector has neglected the smallholders. Maize and beans remain the pillars of food security; however, production especially of yellow maize has drastically reduced due to cheap imports from USA. Although some areas are planted with bio-fuels (cane, palms), maize has potential in Petén, but there is problem to control grain humidity (problems of aflatoxins). Today the topic of food security has gained importance (61% of the rural population in Guatemala is under- or malnourished). In addition, lack of mechanism to stabilize prices lead to decentralized grain storage, and metal silo is an ideal approach.

5.3 Implications for replication

Replication is a sensitive issue, especially regarding approaches involving market mechanisms and food security. Indeed, there have been many technological (GMO boom, internet), economic (globalization, privatization), social (migrations), regulatory (Paris Declaration), and environmental (climate change) changes over the past 20 years leading to major shake ups in the way development programmes are managed. The implications of these changes called into questions the critical factors to be taken into account into these new realities.

In the context of Food Security, sustainability often request public sector to take responsibility into their objectives and planning. On the other side, the experience of Postcosecha shows that it take years to establish a market for a product like the metal silo. From the analysis and discussions with experts, there are three main implications that should be considered in possible replications in order to limit risks and take advantage of existing dynamics.

Tinsmith organizations face many challenges

The strategy of Postcosecha consisting in ensuring a territorial coverage with tinsmith in order to ensure easy access to silo for farmers has shown its limit. During the Programme, tinsmith organizations have expanded rapidly, but many of them have failed, and their existence does not guarantee effectiveness. For that, they need to face major challenges, both internal and external to the organization:

Resolving conflicts between efficiency and equity. Tinsmith organizations typically operate in the context of a rural community where they are subject to norms and rules. This may clash with the requirements of businesses that must help members to compete for their market place. Additionally, organizations may have difficulties to exclude members that do not comply with obligations and standards. An analysis of the survey results shows that today less than 6% of tinsmith is producing more than half of the silos.

Dealing with a changing political environment. However effective they are internally, tinsmith cannot successfully influence pro Food Security Policies. Hence, the demand for metal silos that is highly coming from the public sector (figures show that around 50% of silos are purchased with governmental subsidies.

Focus on innovations, design silo to new demands

Today, the metal silo has been massively adopted by farmers and private and public institutions. Most of the institutions in the region knows and develop this topic. Despite this fact, few tinsmiths (as compared to the number of tinsmith trained) could further develop and expand this activity as a business beyond the “silo model” still being more or less the same as developed twenty years ago. There is a need and opportunity for innovation in order to gain new markets (more well off population, urban populations) with new and innovative products.

Take into consideration the context, have a wider view on Food Security

Surveys show that silo users range from subsistence farmers to farmers with access to farmers. This confirms the existence of two parallel markets for silos: institutional markets for food security, and farmer market. There is a need for a differentiate strategy taking into account different target populations and different needs.

ANNEX: LIST OF EXPERTS INTERVIEWED

El Salvador

	Name	Institution/Function
1.	Douglas Navarro/ Carlos Mata/Miguel Riviera	Unidad Postcosecha, DGSVA. Coordinador / Capacitadores
2.	José Tobias Aparicio; José Lisandro Guzmán	Asoc. de Artesanos Postcosecha de Oriente (APOS)
3.	Ricardo Rodríguez González; Wilfredo Ramírez Escobar	CARITAS
4.	Luis A. González Herazo / Oscar Antonio Amayo	CORDES
5.	Salvador Urrutia	Consultor (ex-ministro de agricultura 1999-2004)
6.	Hugo Alexander Flores	MAG, Viceministro de Agricultura y Ganadería
7.	Keith Andrews	IICA El Salvador, Representante
8.	Edgar Cruz	IICA El Salvador Especialista en competitividad

Guatemala

	Name	Institution/Function
1.	Rolando Ochoa	MAGA, Unidad Ejecutora Postcosecha, Coordinador
2.	Juventino Ruiz	MAGA, Unidad Ejecutora Postcosecha, Asistente técnico
3.	Vitalino Agustin Sisneros	Asoc. de la Seguridad Alimentaria ASEGAL
4.	Edgar Jacinto	FAO Representante
5.	Haroldo Tello	SHARE Facilitador institucional
6.	Danilo Agustin Gonzalez Araúz	MAGA, Sub-gerente Unidad coord. de proyectos Coop. Externa y fondos fideicomiso
7.	Ricardo Bresani	Universidad del Valle, Investigador, especialista en nutricion.
8.	Carlos Anzueto	Consultor (ex Gerente Unidad coord. de proyectos Coop. Externa y fondos fideicomiso 1996-2000),

Honduras

	Name	Institution/Function
1.	Rubén Rodríguez	INFOP, Coordinador
2.	Jeremías López	DINADERS Gerente de operaciones
3.	Alexis Mejía	Artesano Postcosecha propietario de Hojalatería Valle y ex pres. ANAPH
4.	Germán Flores & Jorge Garay	PESA/ FAO Coordinador Nacional
5.	Roni Vaidez	Parroquia de Jutiapa,
6.	Luis Álvarez Welchez	FAO Asesor Técnico (Programas)

Nicaragua

	Name	Institution/Function
1.	Sebastián Salinas	INTA Coordinador subprograma Postcosecha
2.	René Galdámez	CRS (Ex responsable Comm. y monitoreo de Postcosecha)
3.	Dionisio Bismarck Alfaro C.	COPSAPOLAS Pres. Coop.de Servicios Artesanales Post-cosecha “Las Segovias.
4.	Isaac Úbeda	CASPOSEN- Cooperativas Artesanal de Servicios Postcosecha del Norte
5.	Ruth Navarro	Administración
6.	Yasmina Padilla	Save the Children, Coordinadora de Proyecto de Seguridad Alimentaria
7.	Eduardo Baumeister	Investigador
8.	Arcángel Abaunza	MAGFOR, Director Políticas tecnológicas
9.	Ali Jiménez	FAO , Coordinador Programas Conjuntos F-ODM/ONU/FAO

Other (international etc.)

	Name	Institution
1.	Aldo Cardona	Consultor, Ecuador (ex asesor Fomenta-Postcosecha (RELATA)
2.	Gustavo Saín, Jorge Ardila	CESEA, Costa Rica.
3.	Juan Bravo	Consultor, Ecuador (ex coordinador regional Postcosecha)
4.	Kurt Schneider	Helvetas Guatemala, (ex asesor Postcosecha)
5.	Max Streit	SDC, Bern, Switzerland (ex asesor Postcosecha)
6.	Urs Heierli	msd consult, Switzerland

Note: all interviews were conducted directly (face to face) or by telephone/Skype by Robert Berlin, Martin Fischler and Rene Galdámez.

Annex 9: List of participants in validation workshop

Pais/ No	Nombre y apellido	Institución y función	Contacto (email o tel.)
El Salvador			
1	Douglas Navarro	**UCP (**DGSVA/MAG)	postcosecha10@yahoo.com
2	Jose Tobias Aparicio	Pres. coop. de artesanos APOS	via Douglas Navarro
3	Ricardo Villacorta	Coord. estudio	ricervilla@yahoo.es
Guatemala			
1	Rolando Ochoa	MAGA	ppostcosechamaga@yahoo.es 502 53 61 53 94
2	Kurt Schneider	Helvetas	kurt.schneider@helvetas.org
3	Lionel Cifuentes	Coord. estudio	lionelcifuentes@gmail.com
Honduras			
1	Ruben Rodriguez	INFOP Coordinador	230684, Ext.147; Cel. 33943531; rubenrodriguez85@latinmail.com
2	Gilberto Zanabria	INFOP	230684, Ext.147; Cel. 33943531;
3	Alexis Mejia	Artesano Postcosecha ex presidente de ANAPH	Nacaome, Valle ; 33 85 67 63
4	Carlos Alberto Rodriguez Pavon		contacto via Nelson Palacios
5	Nelson Palacios	Coord. estudio	nelsonpalacioshn@yahoo.com
Nicaragua			
1	Sebastián Salinas	UCP/INTA	ssalinas@inta.gob.ni
2	Jorge Bonilla	Artesano instructor	via
3	Miguel Lacayo	Resp. Postcosecha INTA Pac. Sur	mlacayo@inta.gob.ni
4	Alvaro Gutierrez	CASPOSEN Vice-pres.	Wiwili, Jinotega Cel. 84 17 78 72
5	Yazmina Padilla	Save the Children	ypadilla@sc.org.ni
Otros (organizadores, internacionales, etc.)			
1	Yuri Marin	Nitlpan, Investigador	yuri.marin@nitlapan.org.ni
2	Francisco Perez	Nitlapan, Investigador	francisco.perez@nitlapan.org.ni
3	Rene Galdamez	(CRS)	renegalsi@hotmail.com
4	Erick Almendarez	Nitlapan, coord. de campo	via Nitlapan
5	Juan Bravo	Consultor Ecuador	jbalimentoseguro@yahoo.es
6	Caren Pavon	Nitlapan	
7	Franciso Paiz	Nitlapan	
8	Candida Leyton	Apoyo taller	
9	Martin Fischler	Intercooperation, team leader	martin.fischler@intercooperation.ch
25	Total		

Annex 10: Subsidy model used for metal silo dissemination in Guatemala

(source : Case study conducted by Kurt Schneider, 2010)

1. Introduction / Background

The Post Harvest Unit at the Guatemalan Ministry of Agriculture and Livestock (MAGA in Spanish) is responsible for promoting the transfer of metal silos for family use. The silos are available in the following sizes: 400, 800, 1,000, 1,200, 1,500, 1,800 and 3,000 pound-capacity. The transfer process began in 1975 and to date (2010), over 300,000 silos have been distributed in all of the country´s 22 departments or provinces. (See Annex 4 Silo Transfer Statistics.)

Within a framework to ensure food security and improve the quality of life of highly-vulnerable rural populations living in poverty and extreme poverty in Guatemala, MAGA introduced a subsidy model in 2000. The model was included in a decree (No. 1496-2000) issued by MAGA. (See Annex 1) The following sections describe how the subsidy model works and summarizes the results and lessons learned from the experience.

2. Description of the Subsidy Model

a. Concept

The subsidy model is based on State-financing of the zinc sheeting and transportation costs from point of origin to deliver the material to the provincial warehouse facility. The remaining costs are the responsibility of the recipient and will include labour, local transportation and minor expenses for supplies such as soldering material, charcoal, paint, muriatic acid plus tool and equipment depreciation. The State´s contribution equals about 62% of the total cost (See Annex 5 Cost Breakdown of Metal Silos). The subsidy only applies to the 1,200 pound-capacity silo (550 kg). Each family is entitled to only one subsidized silo.

b. Operations

The subsidy model is comprised of fifteen steps, described below:

1. The Post Harvest Unit (UPC in Spanish) prepares forecasts on the number of silos to be transferred annually and submits the estimate to MAGA along with a justification (See Annex 6). The justification includes the following:
    a. Technical specifications for metal silo construction.
    b. Construction diagram for 1,200 pound-capacity post harvest metal silo.
    c. Cost estimates for silo manufacturing.
    d. De-centralized silo manufacturing plan.
    e. Geographic distribution plan.
    f. Budget analysis for resource allocations to procure necessary material.
    g. Matching fund projects from participating communities.
    h. Expected impact from transfers.
2. MAGA approves the budget and number of subsidized silos.
3. UPC sets up a public bidding process to procure zinc sheeting on Guatecompras[6].
4. Once bids are received, an independent MAGA committee performs quality control testing.
5. MAGA issues a technical report.
6. MAGA confirms the procurement of required amount of sheeting and prepares a purchase agreement with the winning company, including payment terms, guarantees and delivery location and date.
7. UPC notifies the regional MAGA offices of the delivery date and coordinates delivery and distribution through the supplier.
8. Sheeting is delivered to the regional warehouse facilities and a receiving committee confirms receipt.

[6] Guatecompras is an official public instrument to collect Price offers in the market

9. The UPC regional coordinator notifies the crafts persons who take delivery of the sheeting and make arrangements to transport the goods to their workshops.
10. The craftsperson closes the deal with the final recipient (producer) and manufactures the silos. This is usually a verbal agreement and does not involve a written contract.
11. The UPC regional coordinator supervises silo quality control.
12. Once the silo is finished, the producer pays the craftsperson and takes delivery.
13. Both the craftsperson and the beneficiary sign a check sheet which is returned toUPC for submission to MAGA accounting offices. (See Annex 10)..
14. The producer has received use and maintenance instructions from the craftsperson.
15. The UPC regional coordinator also signs off on the check sheet to confirm that the silo was delivered.

Once all the proper documentation has been provided to UPC, a financial and technical report is prepared for submission to MAGA and other pertinent authorities involved in the accounting and financial aspects.

c. Oversight and quality control

Once the procurement of the zinc sheeting is approved at the national level, the UPC regional coordinator sets up the MAGA warehouses to take delivery and organizes the crafts persons around regional or community locations. The crafts persons are responsible to taking delivery of the sheeting and transporting it to their workshops.

The UPC regional coordinator provides oversight for the entire regional process. He or she notifies both the crafts persons, as well as the beneficiaries. He or she supervises the quality of the manufacturing process and approves delivery of the finished product. The UPC provides the craftsperson with written material (use and maintenance instructions for the silo) and oversees the training and orientation that the manufacturer provides for the beneficiary.

3. Justification for Introducing the Model

The subsidy model for Guatemala was introduced in 2000, ten years ago. Based on estimates that 245,000 silos were transferred between 2000 and 2010, approximately 209,208 (85%) were subsidized. It is worth mentioning that as of 2005, systematic controls of transferred silos are no longer in place. Many crafts persons are producing and selling silos and are not reporting the numbers to the UPC.

Based on 2008 census data, Guatemala has very high rates of undernourishment among children and pre-teens (43.3% and 45.6% respectively). Local authorities are concerned and have included the following components as part of a comprehensive program for vulnerable populations:

- Promoting food production,
- Promoting access to basic food supplies,
- Promote education on food and nutrition,
- Increase coverage for provision of health and family hygiene services,
- Strengthen institutional capacity.

The program also included promoting conservation and storage techniques for grains by using family silos. Having confirmed the high efficiency of a silo MAGA has opted to introduce a subsidy program for the most vulnerable and impoverished families. At first, the program focused on a region heavily affected by the historical armed conflict and inhabited by displaced populations. Once the success of the subsidy program was established, the program was made a permanent part of the UPC budget. The UPC 2010 budget data is as follows:

- Total Budget: US$ 1.62 Million (100%)
- Subsidy: US$ 1.37 Million (74.5%) (38,602 1200-pound capacity silos)
- Operations: US$ 0.25 Million (15.5%)

The Government has institutionalized the subsidy and it is a component of the overall MAGA budget. Through the Office of the First Lady (SOSEP) and the Ministry of Public Health (MSPAS), the Government implements a program to combat poverty, malnutrition and illiteracy through a package of applied technology. The package includes fertilizers, seeds, irrigation systems, health assistance, foodstuffs and the silo.

4. Beneficiary selection Criteria

The criteria to select beneficiaries are as follows:

- Families in poverty and extreme poverty in rural areas,
- Producers of basic grains,
- Families with children,
- Families residing in communities that have been designated as impoverished (according to the National Plan for Poverty Reduction);
- Families who have been victims of natural disasters such as floods, landslides, etc.

The UPC receives lists of names from the National Program for Poverty Reduction that is managed by the Social Work Office of the First Lady (SOSEP), as well as from the Ministry of Public Health (MSPAS).

5. Selection of Crafts persons for the Post Harvest Silos

The UPC has a roster of approximately 410 crafts persons. They are located throughout the 333 municipal districts in the country. They are independent local manufacturers, although some are members of guilds or associations. The UPC subsidy program assigns each craftsperson the number of silos for production. If the manufacturers are members of a guild or association, the silo production is assigned to the association and it, in turn, decides how to allocate production among its members. The associations charge a quota of about US$ 1 or 2 for each silo they assign to a manufacturer. In return, the manufacturer benefits from the association negotiating wholesale prices for soldering material and other supplies. Nevertheless, not all associations make arrangements for wholesale purchasing. Overall, however, most crafts persons are pleased to join associations or guilds because it may also provide access to credit they use to purchase sheeting and other supplies required for manufacturing additional, non-subsidized silos that they market outside the program. Among the 410 manufacturers on the roster, about 130 belong to a total of nine associations, averaging about 15 manufacturers per association. The subsidy program does not give the associations any preference. A craftsperson can produce an average of about 50 subsidized silos annually.

Associations are also receiving manufacturing contracts to produce silos for other development organizations and, in many cases, portions of the cost are also being subsidized. In some cases, the development organizations pay the entire labour costs and the manufacturer is providing the material.

The crafts persons perceive that commercial demand has waned. Nevertheless, their income has actually increased because the number of subsidized silos has increased. The manufacturers that produce more than 100 silos annually (a combination of both subsidized silos and silos for commercial trade) work full time at this as their source of livelihood with an annual income of approximately US$3,000. This income includes selling of side products of rests of zinc sheeting (hojalateria).

Benefits of Membership in an Association:

Members may enjoy the following benefits:

- They are members of a legally-established association and can negotiate and sign contracts with development organizations (NGOs, co-ops, etc.)
- They have access to credit through the association to purchase supplies and materials.
- They can benefit from consolidated purchases through the association at volume discounts or wholesale prices.

6. Financing

When MAGA first introduced the subsidy model in 2000, the subsidies were financed through the United States Government PL-480 program (proceeds from the sale of food supplies donated by the USG). Subsequently, the Government of Guatemala assigned a budget allocation and took responsibility for the expense. In 2009, the Government signed a three-year agreement (2010 – 2012) with the European Union (EU) as part of the Program to Support National Policy on Nutrition and Food Security in Guatemala and the Strategic Plan to combat malnutrition in the vulnerable populations of rural areas in those municipal districts prioritized by the Government. (See Annex 3). Over the next three years, financing for the subsidy program will come from the EU fund.

7. Sample Data for Crafts persons and Beneficiaries (Producers)

a. Craftsperson (Tinsmith)

Name	Armando Xuyu
Age	30
Location	Chimaltenango
Marital status	married
Number of Children	5
Year received Training	1997
No.of silos produced to date	3000
Annual average	230
Year beginning producing subsidized silos	2002
No. of subsidized silos produced	1200
Association member	no
% income from silo production	100%
Other occupations	manufacturers tin products
Benefits of being an independent manufacturer	Owns his home and a vehicle (older model)
Opinion of the subsidy program	The subsidy program has contributed to lower demand for commercially produced silos, but the number of silos I produce through the program provides me with greater income.
Opinion of the Post Harvest Project	The Post Harvest Project has greatly improved the availability of grain. It has enabled me to improve my socio-economic situation. I have employees. My wife works with me as well, she is also a craftsperson.

b. Producer

Name	María Catalina Cate, head of household
Age	49
Location	San Jacinto, Chimaltenango
Marital status	widow (last 20 years)
Number of Children	3
Land area	0.2 hectares
crops	maize
Main source of livelihood	handicraft production
secondary source	health promoter
First silo /year	1,200-pound capacity/2000
subsidized silo/year	1,200-pound capacity/2008

Contact to provide subsidized silo	Ministry of Health
Criteria met for subsidized silo	Female, impoverished community, grain conservation, limited financial capacity
Opinion of the subsidy program	Very pleased with the silo
Opinion of the Post Harvest Project	Having the silo allows me to keep chickens. I have grain year-round. The Project provided good instructions about using the silo.

8. Lessons Learned

a. Advantages

The subsidy provides an opportunity to make a more direct impact on poverty reduction by ensuring food security. Foreign assistance together with State contributions is invested more efficiently toward the objective of benefitting the most vulnerable and impoverished populations. The Guatemala subsidy model does not affect the supply and demand market concept because the beneficiary must always negotiate a price with the manufacturer or craftsman. Although the profit margin on a subsidized silo is smaller as far as the manufacturer is concerned, the total production volume offsets it and his or her total income is greater. The State benefits as well from an effective approach to poverty reduction. The subsidy could be linked or conditioned along with other mechanisms such as training or health and education services.

b. Disadvantages

There are situations in which farmers with certain financial resources expect to receive a subsidized silo. This could eventually evolve into political favouritism. Individuals may become comfortable with subsidies and have a distorted perception of what things actually cost and could eventually affect market prices for grain.

In some locations, the commercial demand for silos at actual market prices has decreased. This could also affect the business prospects of crafts persons.

c. Conclusions

The subsidy model for silo transfers is a clear manifestation of political will to benefit impoverished populations. If well managed, it could have positive impacts and contribute to improving food security. The subsidy enables certain segments of the population that would otherwise be unable to afford a silo to be able to store grain and avoid purchasing it off-season at much higher prices.

A well-targeted subsidy, linked to a useful product like a silo, is preferable to other types of assistance or donations that merely attack the symptoms (e.g. food distribution).

9. References

a. Persons Interviewed

Name	Position	Institution	Location
Mario Erales	VISAN Advisor	MAGA - VISAN	Guatemala
Rolando Ochoa	UPC Coordinator	MAGA-Guatemala	Guatemala
Juventino Ruiz	UPC Technical Assistant	MAGA-Guatemala	Guatemala
José Luís Chinchilla Vega	UPC Technical Supervisor	MAGA-Guatemala	Guatemala
Ronaldo López	UPC Regional Facilitator	MAGA-Guatemala	Guatemala
Juan Mendoza	UPC Craftsperson Instructor	MAGA-Guatemala	Guatemala
Antonio Curruchich	UPC Craftsperson Instructor	MAGA-Guatemala	Guatemala
Marvin Francisco Sutuj	Craftsperson	self-employed	San Martin Jilotepeque
Armando Xuyu	Craftsperson	self-employed	Chimaltenango
Maria Catalina Cate	Proprietor of 1,200 pound-capacity silo	housewife	San Jacinto, Chimaltenango
Gabriel Sequen Chamale	Proprietor of 1,200 pound-capacity silo	farmer	San Jacinto, Chimaltenango
Jose Gregorio VasquezTikik	Craftsperson	self-employed	Tejar, Chimaltenango
Oscar Anibal Méndez	Craftsperson	self-employed	Nueva Concepción, Esquintla
Rolando López	Proprietor of 1,200 pound-capacity silo	farmer	Santa Clara hamlet, Section 1 in Nueva Concepción, Esquintla
Oscar Armando Hernández Acencio	Craftsperson	self-employed	San Juan Camapa
Alfredo Corado Ozorio	Proprietor of 1,200 pound-capacity silo	Agricultor	Monte Rico village, Ciudad Pedro Alvarado, Jutiapa
Sergio Oswaldo Castillo	Craftsperson	independiente	Progreso, Jutiapa
Edy Humberto CicilianoGonzalez	Craftsperson	independiente	Tinton Sur village, Pasaco, Jutiapa

b. Bibliography

- MAGA, State-supported Post Harvest Technology Transfer Model, Post Harvest Model, 2010
- Ministerial Agreement 1496, MAGA, 30.10.2000
- Ministerial Agreement No. 0245-2010,MAGA,15.11.2010
- Technical Data for Metal Silos, 2010
- Technical report on zinc sheeting procurement, MAGA, 2010
- Purchase Order, FORMA-01-S/P-AC,11.5.2010, MAGA
- Management Requirements for Subsidy Justification OFICIO UCPCG-088-2010,MAGA,13.5.2010
- Purchase Order, SIGES-ORDEN DE COMPRA,OC No.:10.402,MAGA,17.11.2010
- Technical Report: test son sheeting for silo manufacturing

10. Annexes (available on request)

1. Ministerial Agreement 1496-2000

2. Ministerial Agreement No 0245-2010
3. European Union Agreement
4. Silo transfers 1990 to 2010
5. Cost estimates for subsidized metal silos
6. Justification for 1,200-pound capacity silo subsidy
7. Technical Report
8. Interviews with Crafts Persons
9. Interviews with Farmers
10. Check list for silo distribution

Annex 11: Risk assessment of aluminium phosphide

(source: case study conducted by Kurt Schneider, 2010)

1. Introduction / Background

An aluminum phosphide product, generally known as *Phostoxin* or *Phosfamina*, is used as an insecticide for grain conservation treatments. The product has been on the global market dating back over fifty years and due to its effectiveness, low costs and ease of use, has been widely accepted among small farmers as well as for industrial use. Because of its high toxicity, it is classified as such and requires labeling with a red stripe signaling restricted use. The product no longer has patent protection in effect and is being manufactured by a number of laboratories all over the world. The product was initially developed by Bayer.

The product is sold as either tablets or pellets. The former are available in either small bottles (see Annex 1) containing three tablets or larger bottles containing 30 tablets. The product is imported in drums that are properly labeled and marked and contain large quantities. Because it is a highly toxic product, countries have taken various measures to control its application based on the particular circumstances in each country.

The Swiss Agency for Development and Cooperation (SDC) implemented a project on basic grain conservation in Central America that was in effect from 1978 to 2005 (Programme Postcosecha). The Project fostered the use of a number of conservation measures, but in particular, focused on the use of metallic silos that were made available in sizes ranging from a 4-quintal capacity to a 30 quintal one.

The use of phosphide led to a number of incidents linked to its high toxicity and a number of countries have adopted stringent measures to restrict both the accessibility and the applications of the product.

To enable SDC to justify its decision to recommend responsible use of *Phosfamina* as a component of its development programs, we are conducting small surveys to assess the situation and prior experience with the product in Central America.

The following section presents the findings from this quick assessment in Central America and consultations with specialists and official authorities.

2. The Use of *Phosfamina / Phostoxin* (Aluminum Phosphide)

Phosfamina has been widely used by industry in large-scale applications for large silos with capacities ranging from ten metric tons up to 500 metric tons. It is also systematically applied to internationally-traded grain to avoid transferring pests from one country to another. Ships carrying grain fumigate their cargo en route in order to avoid pest contamination in other countries.

Phosfamina has been also in use for small-scale domestic applications by small farmers seeking to ensure food security by conserving their grain in small silos ranging in capacity from 200 to 2000 kilos. The product is easy to apply and very effective.

The COSUDE-supported projects throughout Central America enabled the transfer of more than 500,000 silos with a total storage capacity of approximately 500 metric tons. The treatment required for this amount of grain calls for the application of a total of approximately 2.5 million tablets with an annual cost of US$ 104,000.

a. Poor and Improper Use

Phosfamina products are also applied to eliminate rodents, but do not constitute an appropriate use. Farmers have applied it to treat grain stored in open bags which is not approved due to the fact that the gas does not reach appropriate levels of concentration and presents a risk to humans or animals in the vicinity.

The fact that the products are being used inappropriately has led to unacceptable results and increases the tolerance that insects have developed to the substance.

One of the more significant problems is the abuse of this product is in suicide attempts. According to statistics in Guatemala (see Annex 2), 35% of poisoning caused by pesticides is due to the ingestion of *Phosfamina* tablets, with the highest incidence among individuals in the 15-40 age range. Survey results indicate that this is mainly attributed to its use by heart-broken individuals, hence the nickname-- “love pill.” Over the last five years (2005 to 2009), 90 individuals have died in Guatemala by poisoning from agrochemicals. **However, the use of *Phosfamina* has not been linked to any of the incidents reported based on occupational use.**

The situation led Nicaragua to prohibit open sales of the product in 2004 and El Salvador has regulated and controlled its sale by requiring monthly reports to the Ministry of Agriculture.

b. Survey Results on the Use of *Phosfamina*

In order to assess opinions regarding the use of the *Phosfamina* products, a formal survey was conducted on 11 individuals in four countries (Guatemala, El Salvador, Honduras and Nicaragua) (see Annex 3). In addition to the survey, a number of individuals were interviewed as follows: public officials (3), agricultural extension agents (5), post-harvest tinsmiths (9) and silo proprietors (4). The following information summarizes the results of the survey.

Characteristics of the survey respondents:

- one individual working in the chemical industry
- two individuals specializing in fumigation
- three individuals from international organizations
- two individuals from agrochemical regulating agencies, and
- three post-harvest agricultural technicians.

All respondents felt that is feasible to have small farmers make appropriate use of *Phosfamina* if they received proper instructions and applied care in its handling. Six individuals (55%) were of the opinion that there are no other viable alternatives to replace *Phosfamina*. Other available products are either difficult to apply or are natural products that do not present a real alternative.

Half of the individuals think that the risk faced by small farmers handling the product is minor and 40% think that the risk is high. The risk, however, comes not from handling the product per se, but rather from inappropriate use such as an attempt to commit suicide or an application to eliminate rodents. Nonetheless, all respondents felt that the product should be sold to farmers and, likewise, felt that government authorities should apply more stringent controls, such as the following:

- Prohibition to sell to minors (requiring identification to prove age);
- Sell exclusively through agricultural service providers that are properly registered;
- Sell exclusively to individuals that own a silo;
- Instruct the user by providing training and technical assistance, and
- Provide technical recommendations at the time of sale.

Ninety percent of the respondents are aware of cases in which the product has been used inappropriately and most mentioned voluntary (*sic*) suicide attempts. All the individuals felt that the product does not harm the environment nor does it leave contaminant residue in foods if the recommended period is allowed to elapse between application and food consumption. Specialists indicated that the powdery residue that is left behind on the grain is inert (aluminum hydroxide = clay).

Eight of the 11 individuals surveyed have handled *Phosfamina* personally and are very familiar with it. They consider it easy to handle, without the need for any type of application device, and very effective.

3. Regulations and Application

Phosfamina is sold in all of the six Central American countries but various regulations apply for its sale in each. The following table is a synopsis:

Country	Product is registered and authorized	Sold Freely	Observations
Guatemala	Yes	Yes	
El Salvador	Yes	No	See explanation
Honduras	Yes	Yes	
Nicaragua	Yes	No	See ministerial resolution No. 55-2004
Costa Rica	Yes	Yes	
Panama	Yes	Yes	

The product is registered in each of one of the country´s agrochemical registries and its use has been authorized. Of the six countries, four allow it to be sold feely through authorized dealers (know in Spanish as *agroservicios*). In two of the countries, sales are restricted.

The following section provides more information regarding the restrictions applied by the countries throughout the region:

a. Nicaragua

A ministerial resolution (No. 55-2004) was issued in Nicaragua in 2004 (see Annex 5) to prohibit the importation and sale of the product without prior authorization. Imports have been approved based on verification of the need described by the interested party, the volume of the product to be treated, the storage capacity, and contingent upon evidence that the product will be used exclusively at the facilities of the party making the request and subject to strict controls exerted by MAGFOR.

In light of this situation, access by a small farmer is a very difficult prospect. Nonetheless, reality in the field shows that the product is being used and farmers are obtaining it through a number black-market channels. In certain areas, the product is being transported across the border from Honduras.

b. El Salvador

In the case of El Salvador, the product is sold if certain requirements are met, as follows:

a) It is used exclusively for controlling pests in for stored grain.
b) It may be sold only to individuals of legal age who can prove it by showing their personal identity document (DUI).
c) Importers and dealers should submit monthly sales reports to the Ministry of Agriculture and Livestock (MAG).
d) Sales through *agroservicios* should be limited to providing the product in hermetically-sealed containers with a maximum of three tablets.

Despite these measures, the product is sold practically freely and small farmers have ready access.

c. Guatemala, Honduras, Costa Rica, Panama

The product is sold in these countries through authorized stores, most often through *agroservicios*, and controls are minimal.

4. Danger – Should *Phosfamina* be freely sold to the public?

The answer to this question must be made by weighing the advantages against the disadvantages it may represent for the inhabitants. If in fact it is true that the product is highly toxic, it must be stated that it is very easy to handle and provides a great service to the population: to the small farmer, in particular; and to the population which is poor or with limited resources, in general. The cases of reported suicides in some countries are not limited exclusively to the use of *Phosfamina*, but also involve other agrochemicals. Between 60% and 80% of suicides can be attributed to the use of agrochemicals other than *Phosfamina*. The fact that product distribution is forbidden in Nicaragua and regulated in El Salvador has not lead to a reduction in the number of poisonings due to agrochemical substances. The product is so effective and presents very limited environmental effects that demand for it is so high where it´s sale is forbidden that it has led to the development of a black market that transfers across national borders.

The industrial use of *Phosfamina* is overseen by specialists that are appropriately-equipped and trained by the commercial companies. The product is officially used for special quarantine procedures when grain is found to be infested by insects when coming from another country. However, the use in large quantities in big stores etc. cannot be compared with the small quantities used in metal silos.

There is practically consensus built around the fact that sales should be better controlled and users should be instructed on how to use the tablet and that it should not be sold to children or minors. Guidance should be provided to sales personnel in *agroservicios*. The tablet should not be sold in other types of establishments such as pharmacies or stores selling consumer goods.

5. Alternative Products

At this point, no product presents an affordable and technically-viable alternative that can replace *Phosfamina*. The following table presents a description of the products that are available on the market:

Alternativa Producto	**Presentación**	**Aplicación**	**Remaros**
Deltamethrin	Powder	Wet mist using a spray pump	Requires the small farmer to make a greater investment, does not eliminate eggs or larvae
Actellic	Powder	Mixed into the grain	It requires a lot of work by the small farmer
Traditional products: chili peppers, nim, garlic, limestone, crop residue, ashes	various types, generally ground into powder	Mixed into the grain	Difficult to measure dosages and not always effective
Decis Gran	Powder	Mixed into the grain	Product quality is hard to control
Conservo	Powder	Mixed into the grain	Generic name, product quality is hard to control
GrainPro[7]	Plastic bags and containers	Insert grain into plastic bag –acts by reducing oxygen	not been validated on larger scale

There is significant awareness among wholesale distributors and importers that it is important to instruct users on how to apply the product correctly. Nevertheless, little private investment has been made in technical assistance or training programs. There is little research available for new product development or to confirm the validity of alternative products. The most recent developments include the use of a method based on bags or containers that are effectively controlling postharvest pests by simple eliminating the oxygen (e.g. by burning a candle in the hermetically sealed container). In Central America, this method has just recently been introduced but little information is available.

6. Conclusions and Recommendations

Phosfamina is a very popular product that is in great demand by small farmers as well as for commercial and industrial use. Attempts to control or restrict its sale as is the case in Nicaragua did not yield the expected results.

[7] Trademark

In fact, the results have been the opposite and have led to it being traded on the black market at prices up to ten times higher combined with grain losses from the lack of appropriate conservation treatment.

The potential danger from inappropriate use of *Phosfamina* tablets to commit suicide does exist but the same applies for most other agrochemical products. There are estimates that approximately 35% of all suicidal poisoning by agrochemical products is from *Phosfamina* tablets. However, and more importantly, no occupational accidents have been reported from applying the product.

The market lacks alternative products that are as effective and economically viable for both a small farmer, as they are for a large producer.

In light of the above, the recommendation is that sales to the public should not be restricted, particularly to the small producer. The following measures should accompany the sale of the product:

a) The product should only be used for pest control in stored grains.
b) The product should only be sold to adults of legal age that can provide proof through their respective identity document (*Documento Único de Identidad*).
c) Importers and distributors should submit their distribution and sales reports to the Ministry of Agriculture and Livestock.
d) Sales through *agroservicio*s should take place in hermetically-sealed containers that contain a maximum of three tablets (see Annex 1).
e) Sales through *agroservicios* should be supported by providing instructional brochures on product application.
f) Perform auditing and oversight to ensure compliance with these measures.
g) Post harvest programs should include components to train sales personnel, users, distributors and development agents.

Annexes (available on request):

Annex 1 – Recommended packaging for *Phosfamina* products
Annex 2 a – Poisoning by *Phosfamina* 2006 – 2010, MSPAS
Annex 2b – Poisoning by pesticides – Guatemala – 2010
Annex 2c – Poisoning by pesticides according to age groups -Guatemala – 2010,
Annex 3 a – *Phosfamina* survey results
Annex 3b – *Phosfamina* questionnaire
Annex 4 – Aluminum phosphide safety data
Annex 5 – Ministerial Resolution No. 55 – 2004, Nicaragua
Annex 6 – Regulations for the Law on Agrochemical Product Registration
Annex 7 – Commercial trade registration for aluminum phosphide
Annex 8 – *Phosfamina* technical fact sheet
Annex 9 – *Phosfamina* handling instructions for use in silos
Annex 10 – Department of Sanitation registration certificate – Guatemala
Annex 11 - Delicia – Germany, 13.1.2011
Annex 12 - Blackmailings, Delicia – Germany, 13.1.2011
Annex 13 List of interviewed individuals
Annex 14 – Contact list for registration officials in Central America

Annex 12: Database general impact calculations (source: separate database in EXCEL)

Variable	Country	TOTAL	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL
A. Silo use																													
1a.Total No. of silos transfered (1980-2009)	El Salvador	77'108										2'628	444	2'894	2'053	4'569	3'941	5'408	5'008	3'002	8'812	8'161	2'694	4'523	2'504	2'871	5'831	11'765	**77'108**
(per year)	Guatemala	241'368							372	873	636	716	1'124	3'795	2'884	5'021	8'172	11'167	15'355	17'708	22'588	12'963	9'587	24'178	38'825	33'762	16'565	15'077	**241'368**
	Honduras	228'808	2'082	2'893	1'687	3'788	5'135	3'449	6'625	8'735	7'210	4'021	9'177	11'137	12'408	9'824	10'489	10'557	9'766	6'219	8'645	13'580	11'570	10'325	14'897	23'089	11'500	10'000	**228'808**
	Nicaragua	120'403									2'000	3'000	5'460	5'462	5'462	5'462	5'462	5'462	5'462	5'462	5'462	5'462	25'000	7'300	7'300	7'300	7'300	6'585	**120'403**
	TOTAL	**667'687**	**2'082**	**2'893**	**1'687**	**3'788**	**5'135**	**3'449**	**6'997**	**9'608**	**9'846**	**10'365**	**16'205**	**23'288**	**22'807**	**24'876**	**28'064**	**32'594**	**35'591**	**32'391**	**45'507**	**40'166**	**48'851**	**46'326**	**63'526**	**67'022**	**41'196**	**43'427**	667'687
1b. Total No. of silos transferred (1980-2009)	El Salvador		0	0	0	0	0	0	0	0	0	2'628	3'072	5'966	8'019	12'588	16'529	21'937	26'945	29'947	38'759	46'920	49'614	54'137	56'641	59'512	65'343	77'108	
(accumulated	Guatemala		0	0	0	0	0	0	372	1'245	1'881	2'597	3'721	7'516	10'400	15'421	23'593	34'760	50'115	67'823	90'411	103'374	112'961	137'139	175'964	209'726	226'291	241'368	
	Honduras		2'082	4'975	6'662	10'450	15'585	19'034	25'659	34'394	41'604	45'625	54'802	65'939	78'347	88'171	98'660	109'217	118'983	125'202	133'847	147'427	158'997	169'322	184'219	207'308	218'808	228'808	
	Nicaragua		0	0	0	0	0	0	0	0	2'000	5'000	10'460	15'922	21'384	26'846	32'308	37'770	43'232	48'694	54'156	59'618	84'618	91'918	99'218	106'518	113'818	120'403	
	TOTAL		**2'082**	**4'975**	**6'662**	**10'450**	**15'585**	**19'034**	**26'031**	**35'639**	**45'485**	**55'850**	**72'055**	**95'343**	**118'150**	**143'026**	**171'090**	**203'684**	**239'275**	**271'666**	**317'173**	**357'339**	**406'190**	**452'516**	**516'042**	**583'064**	**624'260**	**667'687**	
2. Total No. of silos ≥ 15 years	El Salvador	3'072																									2'628	444	**3'072**
(amortized silos)	Guatemala	3'721																						372	873	636	716	1'124	**3'721**
	Honduras	54'802																2'082	2'893	1'687	3'788	5'135	3'449	6'625	8'735	7'210	4'021	9'177	**54'802**
	Nicaragua	10'460																								2'000	3'000	5'460	**10'460**
	TOTAL	**72'055**																											**72'055**
3a.Total No. of silos in use (≤ 15 years)	El Salvador	74'036										2'628	444	2'894	2'053	4'569	3'941	5'408	5'008	3'002	8'812	8'161	2'694	4'523	2'504	2'871	3'203	11'321	**74'036**
(per year)	Guatemala	237'647							372	873	636	716	1'124	3'795	2'884	5'021	8'172	11'167	15'355	17'708	22'588	12'963	9'587	23'806	37'952	33'126	15'849	13'953	**237'647**
	Honduras	174'006	2'082	2'893	1'687	3'788	5'135	3'449	6'625	8'735	7'210	4'021	9'177	11'137	12'408	9'824	10'489	8'475	6'873	4'532	4'857	8'445	8'121	3'700	6'162	15'879	7'479	823	**174'006**
	Nicaragua	109'943									2'000	3'000	5'460	5'462	5'462	5'462	5'462	5'462	5'462	5'462	5'462	5'462	25'000	7'300	7'300	5'300	4'300	1'125	**109'943**
	TOTAL	**595'632**	**2'082**	**2'893**	**1'687**	**3'788**	**5'135**	**3'449**	**6'997**	**9'608**	**9'846**	**10'365**	**16'205**	**23'288**	**22'807**	**24'876**	**28'064**	**30'512**	**32'698**	**30'704**	**41'719**	**35'031**	**45'402**	**39'329**	**53'918**	**57'176**	**30'831**	**27'222**	595'632
3b. Total No. of silos in use (≤ 15 years)	El Salvador		0	0	0	0	0	0	0	0	0	2'628	3'072	5'966	8'019	12'588	16'529	21'937	26'945	29'947	38'759	46'920	49'614	54'137	56'641	59'512	62'715	74'036	**74'036**
(accumulated)	Guatemala		0	0	0	0	0	0	372	1'245	1'881	2'597	3'721	7'516	10'400	15'421	23'593	34'760	50'115	67'823	90'411	103'374	112'961	136'767	174'719	207'845	223'694	237'647	**237'647**
	Honduras		2'082	4'975	6'662	10'450	15'585	19'034	25'659	34'394	41'604	45'625	54'802	65'939	78'347	88'171	98'660	107'135	114'008	118'540	123'397	131'842	139'963	143'663	149'825	165'704	173'183	174'006	**174'006**
	Nicaragua		0	0	0	0	0	0	0	0	2'000	5'000	10'460	15'922	21'384	26'846	32'308	37'770	43'232	48'694	54'156	59'618	84'618	91'918	99'218	104'518	108'818	109'943	**109'943**
	TOTAL		**2'082**	**4'975**	**6'662**	**10'450**	**15'585**	**19'034**	**26'031**	**35'639**	**45'485**	**55'850**	**72'055**	**95'343**	**118'150**	**143'026**	**171'090**	**201'602**	**234'300**	**265'004**	**306'723**	**341'754**	**387'156**	**426'485**	**480'403**	**537'579**	**568'410**	**595'632**	595'632
4. Total adjusted grain stored in silos (adj. for % use/filling cap.)	El Salvador		0	0	0	0	0	0	0	0	0	1'730	2'022	3'928	5'279	8'287	10'882	14'442	17'739	19'716	25'517	30'890	32'663	35'641	37'290	39'180	41'288	48'742	
(tons)	Guatemala		0	0	0	0	0	0	216	724	1'094	1'510	2'163	4'370	6'047	8'966	13'717	20'209	29'137	39'432	52'565	60'102	65'676	79'516	101'582	120'841	130'056	138'168	
	Honduras		1'460	3'488	4'671	7'326	10'927	13'345	17'990	24'114	29'169	31'988	38'422	46'230	54'929	61'817	69'171	75'112	79'931	83'108	86'514	92'434	98'128	100'722	105'042	116'175	121'419	121'996	
	Nicaragua		0	0	0	0	0	0	0	0	1'248	3'121	6'529	9'938	13'347	16'756	20'165	23'574	26'983	30'392	33'801	37'211	52'814	57'371	61'927	65'235	67'919	68'621	
	TOTAL		**1'460**	**3'488**	**4'671**	**7'326**	**10'927**	**13'345**	**18'206**	**24'837**	**31'510**	**38'348**	**49'136**	**64'465**	**79'602**	**95'826**	**113'934**	**133'338**	**153'790**	**172'649**	**198'397**	**220'636**	**249'281**	**273'250**	**305'840**	**341'431**	**360'681**	**377'526**	
5. Total grain saved from loss (base: 10%)	El Salvador	37'524	0	0	0	0	0	0	0	0	0	173	202	393	528	829	1'088	1'444	1'774	1'972	2'552	3'089	3'266	3'564	3'729	3'918	4'129	4'874	**37'524**
(tons)	Guatemala	87'609	0	0	0	0	0	0	22	72	109	151	216	437	605	897	1'372	2'021	2'914	3'943	5'256	6'010	6'568	7'952	10'158	12'084	13'006	13'817	**87'609**
	Honduras	149'563	146	349	467	733	1'093	1'334	1'799	2'411	2'917	3'199	3'842	4'623	5'493	6'182	6'917	7'511	7'993	8'311	8'651	9'243	9'813	10'072	10'504	11'618	12'142	12'200	**149'563**
	Nicaragua	59'695	0	0	0	0	0	0	0	0	125	312	653	994	1'335	1'676	2'017	2'357	2'698	3'039	3'380	3'721	5'281	5'737	6'193	6'523	6'792	6'862	**59'695**
	TOTAL	**334'390**	**146**	**349**	**467**	**733**	**1'093**	**1'334**	**1'821**	**2'484**	**3'151**	**3'835**	**4'914**	**6'447**	**7'960**	**9'583**	**11'393**	**13'334**	**15'379**	**17'265**	**19'840**	**22'064**	**24'928**	**27'325**	**30'584**	**34'143**	**36'068**	**37'753**	334'390
	Cumulative:		**146**	**495**	**962**	**1'694**	**2'787**	**4'122**	**5'942**	**8'426**	**11'577**	**15'412**	**20'325**	**26'772**	**34'732**	**44'315**	**55'708**	**69'042**	**84'421**	**101'686**	**121'526**	**143'589**	**168'517**	**195'842**	**226'426**	**260'569**	**296'638**	**334'390**	
6. Value of grain saved from loss Total grain saved from loss (base: 10%)	El Salvador	8'330'249	0	0	0	0	0	0	0	0	0	38'409	44'898	87'195	117'201	183'978	241'577	320'617	393'811	437'686	566'477	685'753	725'127	791'232	827'829	869'790	916'603	1'082'064	**8'330'249**
(US $, effective prices in corresp. year)	Guatemala	19'449'188	0	0	0	0	0	0	4'801	16'069	24'278	33'520	48'027	97'010	134'234	199'040	304'517	448'650	646'838	875'397	1'166'942	1'334'256	1'457'997	1'765'263	2'255'112	2'682'672	2'887'236	3'067'329	**19'449'188**
	Honduras	33'202'877	32'405	77'433	103'690	162'648	242'571	296'253	399'367	535'323	647'542	710'127	852'961	1'026'302	1'219'426	1'372'330	1'535'586	1'667'494	1'774'468	1'845'006	1'920'603	2'052'044	2'178'443	2'236'031	2'331'939	2'579'087	2'695'493	2'708'302	**33'202'877**
	Nicaragua	13'252'321	0	0	0	0	0	0	0	0	27'712	69'281	144'935	220'617	296'299	371'982	447'664	523'346	599'028	674'710	750'393	826'075	1'172'478	1'273'628	1'374'778	1'448'215	1'507'796	1'523'385	**13'252'321**
	TOTAL	**74'234'636**	32'405	77'433	103'690	162'648	242'571	296'253	404'169	551'392	699'533	851'336	1'090'822	1'431'125	1'767'159	2'127'331	2'529'344	2'960'108	3'414'146	3'832'800	4'404'414	4'898'129	5'534'045	6'066'154	6'789'658	7'579'764	8'007'129	8'381'079	**74'234'636**
	Cumulative:		32'405	109'838	213'528	376'176	618'748	915'001	1'319'170	1'870'562	2'570'095	3'421'431	4'512'253	5'943'377	7'710'537	9'837'867	12'367'211	15'327'319	18'741'465	22'574'265	26'978'679	31'876'808	37'410'852	43'477'006	50'266'664	57'846'428	65'853'557	74'234'636	
	in millions		0	0	0	0	1	1	1	2	3	3	5	6	8	10	12	15	19	23	27	32	37	43	50	58	66	74	
B. Silo production (tinsmiths, traders)																													
1.Silo			Honduras: precio era 60 US $ (Gladstone et al. 2002)									Promedio regional: 50 US $ (Gladstone et al., 2002, Anexo VI)											Survey 2010: 2004, 2008, 2009						
Price per sold silo 18 qq. (average per country in US $)			60	60	60	60	60	60	60	60	60	50	50	50	50	50	50	50	50	50	50	50	70	70	70	70	90	90	
Gross margin acc. to average silo size per country:	size (qq.):																												
- El Salvador	17	1'135'949	0	0	0	0	0	0	0	0	0	31'025	5'242	34'165	24'237	53'940	46'526	63'844	59'122	35'440	104'031	96'345	44'526	74'755	41'386	47'451	123'909	250'006	**1'135'949**
- Guatemala	15	3'224'985	0	0	0	0	0	0	4'650	10'913	7'950	7'458	11'708	39'531	30'042	52'302	85'125	116'323	159'948	184'458	235'292	135'031	139'810	352'596	566'198	492'363	310'594	282'694	**3'224'985**
- Honduras	18	3'478'515	31'230	43'395	25'305	56'820	77'025	51'735	99'375	131'025	108'150	50'263	114'713	139'213	155'100	122'800	131'113	131'963	122'075	77'738	108'063	169'750	202'475	180'688	260'698	404'058	258'750	225'000	**3'478'515**
- Nicaragua	16	1'674'122	0	0	0	0	0	0	0	0	26'667	33'333	60'667	60'689	60'689	60'689	60'689	60'689	60'689	60'689	60'689	60'689	388'889	113'556	113'556	113'556	146'000	131'700	**1'674'122**
Gross margins tinsmiths (based on 25% margin/sold silo)	TOTAL	**9'513'572**	31'230	43'395	25'305	56'820	77'025	51'735	104'025	141'938	142'767	122'079	192'329	273'598	270'067	289'731	323'452	372'819	401'834	358'325	508'074	461'815	775'700	721'594	981'837	1'057'427	839'253	889'400	**9'513'572**
2. Side products																													
Price per metal sheet (average per country in US $)			8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	8.0	8.0	8.0	9.0	9.0	9.0	9.0	13.0	13.0	
Gross margin on metal sheets used (adj. for average silo size/country):	size (qq.):																												
- El Salvador	17	**295'749**	0	0	0	0	0	0	0	0	0	8'042	1'359	8'856	6'282	13'981	12'059	16'548	15'324	10'207	29'961	27'747	10'305	17'300	9'578	10'982	32'216	65'002	**295'749**
- Guatemala	15	**808'845**	0	0	0	0	0	0	1'116	2'619	1'908	1'933	3'035	10'247	7'787	13'557	22'064	30'151	41'459	53'124	67'764	38'889	32'356	81'601	131'034	113'947	80'754	73'500	**808'845**
- Honduras	18	**871'174**	7'495	10'415	6'073	13'637	18'486	12'416	23'850	31'446	25'956	13'028	29'733	36'084	40'202	31'830	33'984	34'205	31'642	22'388	31'122	48'888	46'859	41'816	60'333	93'510	67'275	58'500	**871'174**
- Nicaragua	16	**418'625**	0	0	0	0	0	0	0	0	6'400	8'640	15'725	15'731	15'731	15'731	15'731	15'731	15'731	17'478	17'478	17'478	90'000	26'280	26'280	26'280	37'960	34'242	**418'625**
Gross margins tinsmiths (based on 5% per metal sheet sold at double price)		**2'394'393**	7'495	10'415	6'073	13'637	18'486	12'416	24'966	34'065	34'264	31'643	49'852	70'917	70'001	75'098	83'839	96'635	104'155	103'198	146'325	133'003	179'519	166'997	227'225	244'719	218'206	231'244	**2'394'393**
3. Silo + side products																													
Gross margin tinsmiths silo + side products (1. + 2.)	TOTAL	**11'907'965**	38'725	53'810	31'378	70'457	95'511	64'151	128'991	176'003	177'031	153'722	242'181	344'514	340'069	364'829	407'291	469'453	505'989	461'523	654'399	594'818	955'219	888'592	1'209'062	1'302'146	1'057'458	1'120'644	**11'907'965**
4. Metal sheet traders																													
Gross margin on metal sheets sold (adj. for average silo size/country):																													
- El Salvador	17	**443'624**	0	0	0	0	0	0	0	0	0	12'063	2'038	13'283	9'423	20'972	18'089	24'823	22'987	15'310	44'941	41'621	15'457	25'951	14'367	16'472	48'324	97'502	**443'624**
- Guatemala	15	**1'213'267**	0	0	0	0	0	0	1'674	3'929	2'862	2'900	4'552	15'370	11'680	20'335	33'097	45'226	62'188	79'686	101'646	58'334	48'534	122'401	196'552	170'920	121'132	110'251	**1'213'267**
- Honduras	18	**1'306'761**	11'243	15'622	9'110	20'455	27'729	18'625	35'775	47'169	38'934	19'542	44'600	54'126	60'303	47'745	50'977	51'307	47'463	33'583	46'683	73'332	70'288	62'724	90'499	140'266	100'913	87'750	**1'306'761**
- Nicaragua	16	**627'938**	0	0	0	0	0	0	0	0	9'600	12'960	23'587	23'596	23'596	23'596	23'596	23'596	23'596	26'218	26'218	26'218	135'000	39'420	39'420	39'420	56'940	51'363	**627'938**
Gross margins traders metal sheets (15% margin on sold sheets)		**3'591'589**	11'243	15'622	9'110	20'455	27'729	18'625	37'449	51'098	51'396	47'464	74'778	106'375	105'002	112'647	125'758	144'952	156'233	154'796	219'488	199'504	269'279	250'496	340'838	367'078	327'308	346'866	**3'591'589**