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Summary report on a survey of grain storage options

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Introduction

In February 2015, a questionnaire was designed to survey grain postharvest specialists about their experience of grain store types that development organisations could promote as components of postharvest loss reduction campaigns. A separate form was used to report on each grain store type and respondents were free copy the form in order to report on all the different store types for which they have had experience. The questionnaire is presented in Annex 1.

The purpose in gathering these data was to collect current information with which to populate storage option web pages on the new FAO Postharvest Loss Reduction Community of Practice website. This is being done to help practitioners compare store types and be able to select the most appropriate type for a given purpose. It is hoped that the insights gained from the data may also stimulate further research into store design.

The questionnaire was circulated to 61 postharvest specialists, with a one month reply period. There were 29 respondents, based in a wide range of countries (Fig. 1). Some, but not all, respondents wished for their contributions to be acknowledged. These people are listed in Annex 2.

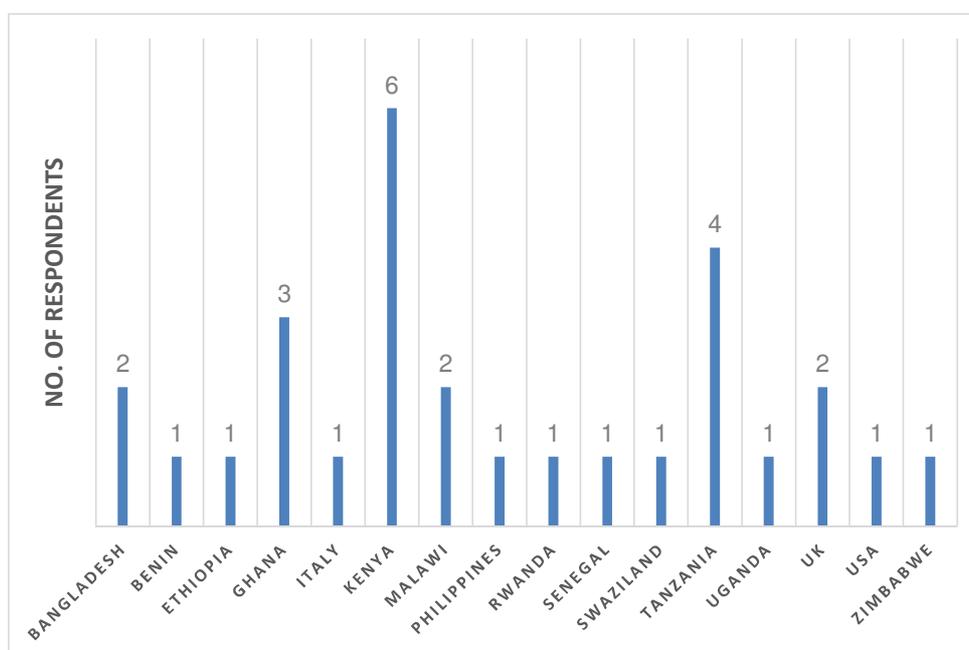


Figure 1 – The countries in which respondents were based

Many respondents dealt with more than one store type and altogether they completed 64 storage options questionnaires covering a wide range of store types (Fig.2).

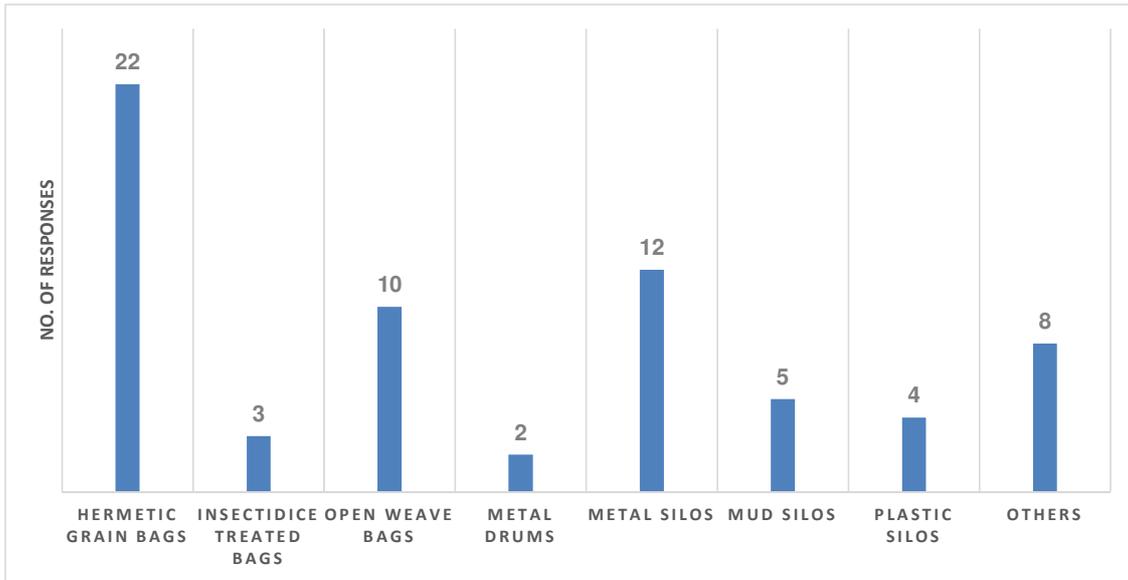


Figure 2 – The number of responses received for each store type

The most numerous responses were for hermetic grain bags. Five hermetic bag types were reported on, the most frequent being the PICS triple-layer bag (Fig. 3).

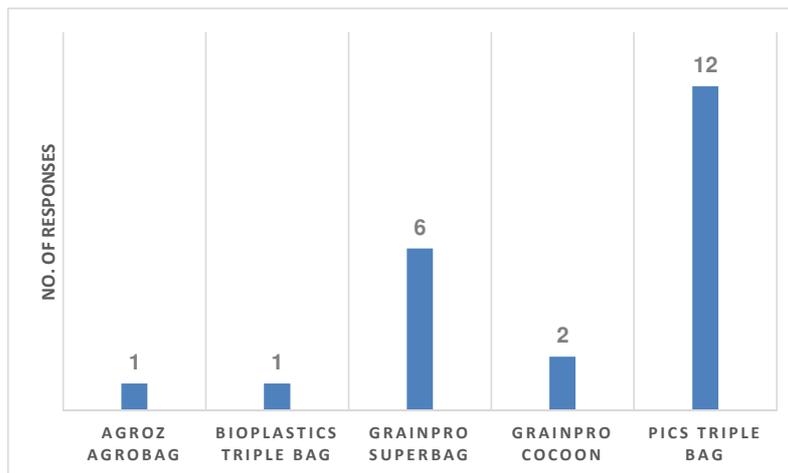


Figure 3 – The number of responses for various hermetic grain bags

The following account is based on information submitted by respondents. To aid clarity and balance, on occasion data from the postharvest scientific literature has also been added. Where this has been done the bibliographical reference is shown.

Summary of responses on grain storage options

A. Commodities stored and store capacity

All the store types for which data have been submitted are intended for use by smallholders or farmer groups for storing cereals, pulses or oilseeds – provided that they have been sufficiently dried. Although some of the more recently developed stores have been tested on only a narrow range of crops, technically there are few reasons why they would not be appropriate for a wider range. One constraint is the different pests associated with different commodities and in particular the Larger Grain Borer (*Prostephanus truncatus*) that infests maize. There have been concerns about the ability of this pest to both bore out from, and into, storage bags and drums constructed with plastic. This would damage the hermetic seal on which these stores rely for the quality preservation of maize. This still remains a concern and a good body of independently verified further field data is required before definitive advice can be given.

In some cases, beverage crops such as coffee and cocoa are included although these crops are not normally stored by smallholders for long enough to justify investment in anything other than basic storage arrangements such as open weave bags. However, more expensive options such as hermetic bags could be applied at major assembly centres where storage periods would be long enough to justify the additional expense. It might also be possible to supply smallholders with hermetically sealable bags as part of an integrated value chain.

The capacities of stores vary widely. Grain bags, both hermetic and open weave, typically hold 50, 90, 100 or 120kg of maize. Larger capacity fully sealed plastic structures holding 1 to 300 tonnes are also available (GrainPro GrainSafe® and Grain Cocoon®). Metal drums hold 90, 135 or 180kg, metal tanks and metal silos 90kg to 3 tonnes. Plastic silos are basically plastic drums or modified water tanks and vary from 100 to 4 t. Locally constructed mud or concrete silos have capacities ranging from 250kg to 10 tonnes. A variety of other improved granaries offer capacities of 1 to 50 tonnes.

Table A1. Overview of commodities stored and storage capacities of different store types

HERMETIC BAGS	PICS bag	<p>Commodities - Maize (Benin, Ghana, Kenya, Niger, Rwanda, Malawi, Senegal, Tanzania, Zimbabwe); Millet (Senegal); Sorghum (Senegal, Tanzania, Zimbabwe); Rice (Tanzania); Cowpea (Benin, Burkina Faso, Cameroon, Ghana, Mali, Niger, Nigeria, Togo, Senegal, Chad); Beans, pigeon peas (Tanzania); Green grams (Kenya, Uganda and Tanzania); Groundnut seeds (Senegal); Pigeon pea (Kenya); Dolicos (Kenya); Common beans (Kenya). In West Africa mostly cowpea due to high value. Statement by Purdue University - all pulses and cereals we have tested are well protected (maize, sorghum, wheat, millet, rice, common bean, cowpea, peanut, Bambara nuts, pigeon pea, mungbean, chickpea, sesame, etc.)</p> <p>Capacity - 50/100kg</p>
	GrainPro Supergrainbag®	<p>Commodities - Maize, sorghum, millet (Uganda, West Africa); Fonio (West Africa); Rice (milled) (SE Asia); Cowpea (West Africa, Uganda); Groundnut, soya (West Africa); Coffee (Ethiopia, SE Asia); cocoa (Manufacturer)</p> <p>Capacity - 50/90kg</p>
	Bio-Plastics triple bag	<p>Commodities - Experience limited to Ghana, so far maize, cowpea,</p>

		sorghum, millet, groundnut in descending volume Capacity -50 and 120kg (more common)
	AgroZ Agrobag® & Agrobag plus®	Commodities - Tanzania - Cereals and pulses (intended) Capacity - 90kg
HERMETIC COCOONS	GrainPro cocoon®	Commodities - Any cereal grains or pulses Capacity - 1–300 tonnes
	GrainPro GrainSafe II®	Commodities - Any cereal grains or pulses Capacity –up to 1 tonne
OPEN-WEAVE BAGS	Polypropylene bag	Commodities - All cereals, pulses and oilseeds Capacity - In different countries the sacks sizes vary -Malawi and Zimbabwe 50kgs, Kenya 90kg, Tanzania 100kg.
	Jute sack	Commodities - Maize, sorghum – Kenya, Malawi, Ghana; Millet – Kenya & Malawi; Cowpea – Kenya & Malawi; Rice – Ghana; Pigeon pea – Kenya & Malawi; Common beans – Kenya & Malawi; Dolicos - Kenya; Groundnuts – Malawi, Ghana; Pulses – Ghana; Bambara nuts, and soya- Malawi. Capacity – 80-100kg
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	Commodities - Maize, rice, wheat, millet, sorghum, beans, groundnuts, cowpeas, soya (Manufacturer); Maize and sorghum - Zimbabwe & Tanzania; Rice, and millet, beans, cowpeas and pigeon peas - Tanzania. Capacity - 50 & 100kg
METAL CONTAINERS	Metal silos	Commodities - Maize, cowpea, sorghum, and beans- Uganda; Maize, sorghum, millet and beans – Kenya; Maize - Malawi, Zambia, Tanzania; Paddy rice - SE Asia. Capacity - 90kg to 3 tonnes
	Metal tanks	Commodities - Cereal grains, especially maize (Africa)and paddy rice (Bangladesh) Capacity - 200kg to 2 tonnes
	Metal drums	Commodities - Mostly maize but are suitable for any dried cereal grains or pulses Capacity - drums are available in volumes of 100L, 150L, or 200L that would typically hold about 90, 135 or 180kg of cereal grain.
CONCRETE SILOS		Commodities - Mostly maize grain but can also be used to store sorghum, millet, groundnuts in shell, pigeon pea and cowpea (Malawi) Capacity – 2-10 tonnes
MUD SILOS		Commodities - All type of grains and pulses can be stored but with more frequency maize, cowpea and very less in cassava, rice and sorghum (Mozambique)

		Capacity - 250kg – 4 tonnes
PLASTIC DRUMS / SILOS		Commodities - Maize, cowpea, sorghum, bean (Uganda) maize sorghum millet (Tanzania), pigeon peas and beans (Tanzania), maize (Kenya), rice (Bangladesh) Capacity – 100kg to 5 tonnes
OTHER IMPROVED STORES	Improved brick granary with compartments	Commodities - All cereal grains (Zimbabwe) Capacity -3.2 tonnes
	Improved woven basket granary (kihenge)	Commodities - Cereals - maize, sorghum, rice, and millet, Pulses - beans, cowpeas and pigeon peas (Tanzania) Capacity - 1 to 5 tonnes
	Improved farmer granary	Commodities - Paddy rice storage (Cambodia) Capacity - 1-20 tonnes
	Gorongosa mud granary	Commodities – All dried cereals and pulses Capacity – approx. 1t of maize is standard, but there are plans for capacities of 0.56 to 1.6t

B. Construction of the stores and their manufacture

Reported store types present a wide range of different construction materials, plastics of various sorts, metal, concrete, mud and wood.

Among the hermetic grain bags (50 - 120kg capacity) there is an option of a single impermeable bag (GrainPro SuperGrainbag®, AgroZ agrobags®) or two impermeable bags one inside the other (PICS bags, Bio Plastics bags). In both case, smallholder would place these in an open weave polypropylene bag to provide protection from puncture. Impermeable grain bags are typically high density polyethylene (HDPE) and interestingly there is a biodegradable version (Bio Plastics bag), although it appears not to have been very extensively tested yet. Larger hermetic structures (200kg to 300 tonnes) are available in PVC with a gas tight zipper (GrainPro Grainsafe® and Grain Cocoon®). All the GrainPro products are manufactured in the Philippines, while AgroZ agrobags® are made in Tanzania. PICS bags are manufactured in many locations across Africa and Bio Plastics bags in Ghana.

Open weave storage bags may be constructed of polypropylene or jute, and in one case bags (Zerofly bag®) are constructed using polypropylene strands with the insecticide deltamethrin incorporated them to protect the crop from insect infestation. Open weave bags of polypropylene are widely produced in Africa while those with insecticide incorporated are manufactured in Vietnam. Jute bags are supplied from Bangladesh.

There are three variants of metal storage container, generally the small capacity ones are metal drums, typically old fuel drums or drums purpose-built as grain stores, metal silos from galvanised flat metal sheet, or metal tanks from galvanised corrugated sheet. Drums may be manufactured locally or imported and are frequently recycled fuel drums, the metal silos are manufactured locally, often close to where they will be used. Other drums/silos may also be constructed from concrete, mud or plastic. The mud or concrete silos are constructed by local artisans while plastic ones are either imported or manufactured locally. The plastic drums/silos range from all purpose storage bins to larger modified water tanks.

Some traditional granaries have been improved and enlarged to provide more extensive capacity and superior protection, these include a brick built structure (Zimbabwe), a storage basket (*kihenge*, Tanzania) and stores upgraded with sheeting, rat guards etc.(Cambodia).

Table B1. Overview of the construction materials and manufacture of different store types

HERMETIC BAGS	PICS bag	<p>Construction - Two inner layers of high density polyethylene 80 microns thick held inside a third bag made of woven polypropylene.</p> <p>Manufacture - the bags are being manufactured in the following African countries, although they are also made in India and Nepal:</p> <ol style="list-style-type: none"> 1. Senegal – COFISAC, Dakar 2. Mali – EmbalMali, Bamako 3. Mali - Emballage Miankala, Koutiala 4. Burkina Faso – Fasoplast, Ouagadougou 5. Nigeria - Lela Agro- Kano 6. Ghana - Polytank, Accra 7. Ethiopia - SePCo, Addis Ababa 8. Tanzania - PPTL, Tanga 9. Rwanda – Ecoplastic, Kigali 10. Malawi - Polypack Blantyre 11. Kenya – Wonderpack, Nairobi
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		13. Uganda - Luuka Plastics, Kampala 14. Afghanistan - Shindand, Herat 15. Zambia - Polythene products 16. Zimbabwe - City Plastics
	GrainPro SuperGrainbag®	Construction – An inner plastic liner composed of a 3-layer plastic laminate. The inner liner is placed inside an outer bage of woven polypropylene. Manufacture – GrainPro in the Philippines
	Bio-Plastics triple bag	Construction - Plastics (Polyethylene) in a biodegradable formulation. The inner liner is placed inside an outer bage of woven polypropylene. Manufacture - Bio Plastics, Accra Ghana
	AgroZ Agrobag® & Agrobag plus®	Construction - A mixture of HDPE and other grades of polyethylene. An special LGB impermeable layer is incorporated in with the bag construction in the case of Agrobag plus. Manufacture - Arusha, Tanzania, by A To Z Textile Mills Limited
HERMETIC COCOONS	GrainPro cocoon®	Construction - PVC sheets with air tight zipper for sealing Manufacture – GrainPro in the Philippines
	GrainPro GrainSafe II®	Construction – PVC sheeting and a patented gas-tight zip Manufacture – GrainPro in the Philippines
OPEN-WEAVE BAGS	Polypropylene bag	Construction – Open-weave polypropylene strips Manufacture –made in most East and Southern Africa countries, often by companies associated with a milling enterprise, as well as specific packaging companies. For example, in Tanzania: Raffia Bag Co in Dar es Salaam; Ashraf in DSM; polypropylene (PPTL) (T) in Tanga; also several Chinese companies import to Tanzania and sell in bulk in Dar es Salam. Kenyan users complain that their Kenyan PP bags rip nowadays when just lifting or loading them. UV resistant bags are made Treger Products (Bulawayo, Zimbabwe).
	Jute sack	Construction - Jute fibre Manufacture – Mostly Bangladesh
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	Construction –open-weave polypropylene strips and deltamethrin Manufacture –Vietnam, Vestergaard Group S.A
METAL CONTAINERS	Metal silos	Construction - galvanised metal sheet (0.5mm thick or 26 gauge), and solder (50:50 lead:tin) Manufacture –constructed locally by artisans trained (and often supplied) by metal silo projects. Also Kenya has a company (Ekima) that is supplying them. Where possible the structures are constructed close to where they will be used to avoid the transporting of large awkward structures.
	Metal tanks	Construction -Corrugated iron sheet

		Manufacture –Manufactured locally and typically made to order
	Metal drums	<p>Construction - Sheet metal</p> <p>Manufacture –Usually purchased from a developing country source, typically China or Vietnam. However, local manufacture not difficult as the technology is 19th century and simple. Importation of sheet metal is much more efficient than the import of drums which occupy a large volume in stowage. Local manufacture would be the way to go for large drum distribution programmes.</p>
CONCRETE SILOS		<p>Construction - Made of wooden/bamboo frame smeared/plastered with cement and sand (50% river sand and 50% dambo sand) mixture (1:4 ratio)</p> <p>Manufacture –constructed in the farm household by community builders and artisans that were trained in Malawi. Sand, labour and poles contributed by beneficiary community/farmer.</p>
MUD SILOS		<p>Construction - Termite hill mud, normal mud, straw; sometimes wood if bigger size; metal or plastic for outlet, may be elevated on legs if so then can have metal rat guards on them. Some stores may have separate compartments for different grains.</p> <p>Manufacture –Local construction by traditional artisans. In some places these skills are rare.</p>
PLASTIC DRUMS/ SILOS		<p>Construction -Same quality of plastic as used in water tanks. In some cases inlet widened to facilitate grain loading.</p> <p>Manufacture –Local plastics industry or imported.</p>
OTHER IMPROVED STORES	Improved brick granary with compartments	<p>Construction - Brick pillars, wire-mesh reinforced concrete slab, brick wall, thatch grass roof</p> <p>Manufacture –local in Zimbabwe</p>
	Improved woven basket granary (<i>kihenge</i>)	<p>Construction -Traditional improved vihenge are made from bamboo sticks or a certain type of tree sticks. After making a skeleton structure, they are then plastered with mud mixed with cow dung and ash. They differ in size. The improvements are:- 1. Raised platform from the floor, 2. Addition of rat guarding materials, 3. Cover on top after grain filling, 4. Proper cleaning and treating with pesticide, 5. Addition of a roof to protect from direct sunlight and rainfall, 6. An outlet port</p> <p>Manufacture –local in Tanzania</p>
	Improved farmer granary	<p>Construction - Farmers traditional materials, added wire mesh (rodent and bird protection), rodent guards, plastic sheets, and good storage and integrated pest management</p> <p>Manufacture – local in Cambodia</p>
	Gorongosa mud granary	<p>Construction - Iron rods, mud bricks, a cement base and cover, and a cement outlet port that can be padlocked. Built on four rocks to raise it off the ground and placed under a thatch shelter.</p> <p>Manufacture – Local trained artisans</p>

C. Costs and subsidies

Basic costs vary widely, even amongst the same store types in different countries, e.g. metal silos of 100kg capacity are said to vary from US\$30 to US\$70. There may be several factors behind this, not least that lower figures could be cost of production or a cost that includes some degree of subsidy, or marketing costs or the profit margin for the producers have been omitted. In some cases it has been difficult to obtain figures since the products are not yet fully commercialised (e.g. Zerofly® bags, AgroZ Agrobag® & Agrobag plus®).

Some large development projects will either defray some of the costs of stores, e.g. the transport costs to the smallholder or even pay some of the cost of the structure itself. For promotional purposes they may even provide demonstration stores completely free of charge. But it would seem that very few smallholders benefit from any kind of subsidy. It is also relatively rare that governments offer any concessions, exceptions are that in Ghana the Bio Plastics bags are subsidised by 33% but this is being phased out, in Tanzania PICS bags have been exempt from VAT, and in Kenya GrainPro products are not subject to import duty.

Table C1. Overview of the costs of stores and any subsidies applied to of different store types

HERMETIC BAGS	PICS bag	<p>Costs - Varies by location but ranges from US\$2.00 –US\$ 4.00 per bag of 100kg capacity.</p> <p>Subsidy - During a 2013 awareness campaign in Rwanda government subsidised by 33%. Also some subsidy in Ghana and Togo by NGOs. In most countries there are no concessions but in Tanzania there is VAT relief.</p>
	GrainPro SuperGrainbag®	<p>Costs - US\$ 2.00 – US\$5.00 depending on supply chain, import taxes etc. Details from GrainPro distributors, US\$2.5 (Uganda), the full kit US\$4.5 (i.e. with outer PP bag in Zimbabwe), the IV-R variant US\$3.1 (Kenya)</p> <p>Subsidy -In SE Asia IRRI gives them as incentives to join up to projects. In Zimbabwe have been provided gratis. Otherwise at commercial cost. In Kenya, GrainPro has negotiated duty free imports.</p> <p>In some Asian countries (Bangladesh) use of plastic is forbidden without a re-cycling scheme or very high import taxes are levied as they are not classed as agricultural tools. Vietnam does not include them in government extension programs because they are imported. In Kenya, GrainPro has negotiated duty free imports</p>
	Bio-Plastics triple bag	<p>Costs -GhC4.5 = US\$4.2 (Apr 2015)</p> <p>Subsidy -30% government subsidy but this is being phased out.</p>
	AgroZ Agrobag® & Agrobag plus®	<p>Costs -Price on application to A To Z Textile Mills Limited</p> <p>Subsidy - NA</p>
HERMETIC COCOONS	GrainPro cocoon®	<p>Costs -In Zimbabwe –</p> <p>50MT Cocoon with a shade and repair kit – US\$7640</p> <p>20MT Cocoon with shade & repair kit – US\$5240</p> <p>10MT Cocoon with shade & repair kit – US\$3140</p>

		5MT Cocoon with shade & repair kit – US\$2100																																				
		Subsidy - In Kenya, GrainPro has negotiated duty free imports																																				
GrainPro GrainSafe II®		Costs -Kenya - including a frame to hold it up (essential) - US\$260 to US\$280. In Zimbabwe - 1 tonne for bagged grain – US\$350, 1 tonne for loose grain – US\$389																																				
		Subsidy -NGOs provide 100% subsidy at times in Kenya and Rwanda. In Kenya, GrainPro has negotiated duty free imports.																																				
OPEN-WEAVE BAGS	Polypropylene bag	Costs - 100Kg bag - US\$0.75 (Kenya), US\$0.37-0.39 (Tanzania); 50kg bag - US\$0.28-0.65 depending on quality (Kenya); Others Malawi US\$0.23-0.45, Tanzania US\$0.5 - 1.0, Zimbabwe US\$0.5																																				
		Subsidy -NA																																				
	Jute sack	Costs -A large jute bag (100kg) US\$4 (Ghana)																																				
		Subsidy -NA																																				
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	Costs -Prices not well established. Manufacturer indicates FOB costs are for 50kg bag US\$0.8 and 100kg US\$1.2. To access them for trials in Zimbabwe cost US\$6/unit.																																				
		Subsidy -NA																																				
METAL CONTAINERS	Metal silos	Costs – Costs in the graph below do not include any transport costs																																				
		<table border="1"> <caption>Silo costs (US\$) by capacity and country</caption> <thead> <tr> <th>Capacity (tonnes)</th> <th>Uganda</th> <th>Kenya</th> <th>Malawi</th> <th>Zambia</th> <th>Zimbabwe</th> </tr> </thead> <tbody> <tr> <td>0.1 t</td> <td>55</td> <td>70</td> <td>30</td> <td></td> <td></td> </tr> <tr> <td>0.5t</td> <td>125</td> <td>145</td> <td>123</td> <td>50</td> <td></td> </tr> <tr> <td>1t</td> <td>180</td> <td>250</td> <td>150</td> <td>173</td> <td></td> </tr> <tr> <td>2t</td> <td>275</td> <td>400</td> <td>200</td> <td>265</td> <td></td> </tr> <tr> <td>3t</td> <td>360</td> <td>590</td> <td>350</td> <td>240</td> <td></td> </tr> </tbody> </table>	Capacity (tonnes)	Uganda	Kenya	Malawi	Zambia	Zimbabwe	0.1 t	55	70	30			0.5t	125	145	123	50		1t	180	250	150	173		2t	275	400	200	265		3t	360	590	350	240	
Capacity (tonnes)	Uganda	Kenya	Malawi	Zambia	Zimbabwe																																	
0.1 t	55	70	30																																			
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1t	180	250	150	173																																		
2t	275	400	200	265																																		
3t	360	590	350	240																																		
		Subsidy - 50% by the SDC/CIMMTY project and 70% by WFP in Uganda and 70% by FAO in Malawi																																				
	Metal tanks	Costs -200kg - US\$12.7 (Bangladesh), 700kg - US\$125 (Swaziland)																																				
		Subsidy -NA																																				
	Metal drums	Costs -Drums are usually purchased second hand and can be obtained for around US\$30. This would apply in most developing countries (although specific experience relates to East Timor in 2011). If drums were manufactured locally costs could be lower.																																				
		Subsidy - In East Timor farmers under ‘Drums on Farms’ could buy																																				

		drums for only US\$10, at least US\$20 subsidy since this included the delivery of a drum to their farm. Another project by CARE exchanged drums for 10kg of maize (value US\$7.50)
CONCRETE SILOS		<p>Costs -2,000kg = US\$261, 3,000kg = US\$280, 5,000 tonne = US\$395, 10,000kg = US\$514</p> <p>Subsidy - No subsidies but the initial beneficiaries received the structures free of charge as a demonstration.</p>
MUD SILOS		<p>Costs -Malawi – 500kg = US\$27, 2,500 tonne = US\$136</p> <p>Subsidy -NA</p>
PLASTIC SILOS		<p>Costs -US\$40 for 200kg</p> <p>Subsidy -One case of WFP in Uganda offering 70% to about 4,000 farmers</p>
OTHER IMPROVED STORES	Improved brick granary with compartments	<p>Costs -Full costing about US\$600</p> <p>Subsidy -Beneficiary provides locally available material such as pit and river sand, water, in some cases crushed stones (as concrete), and sometimes thatch grass. Fire-burnt bricks are usually bought at local price. The rest is often provided by external agents.</p>
	Improved woven basket granary (kihenge)	<p>Costs -Costs vary according to availability of material used. In Tanzania the estimated price at present after addition costs for improvement is US\$31 for 1 tonne structure and US\$142 for a 5 tonne structure in year 2015.</p> <p>Subsidy - NA</p>
	Improved farmer granary	<p>Costs -Used farmers granaries, spent between US\$20 and US\$200 for materials to improve them. Usually done as a village activity.</p> <p>Subsidy -All improvements were initially subsidized, farmers followed some elements using own funds later.</p>
	Gorongosa mud granary	<p>Costs - Full costs of standard capacity approx. US\$70 (2006). Current cost (2015) likely to around US\$140.</p> <p>Subsidy - The 'Sofala Integrated Program for Food Security' in Mozambique, subsidized building materials and some of the labour so that US\$50 (71%) was contributed by the project and US\$20 (29%) was contributed in kind by the beneficiary household.</p>

D. Life span and residual value

Authoritative data on store life span is hard to come by since many of the newer store types have not been used over long periods and even with well-established store types there is inevitably considerable variation due mostly to the how well they are maintained. Other sources of variation will be due to the quality of manufacture and this seems particularly to be the case for polypropylene bags. Nevertheless it is possible to arrive at general statements about longevity based on the durability of the construction materials. Open weave polypropylene bags last 1-2 years and jute bags 2 or more years. Insecticide incorporated open weave polypropylene bags are expected to last 2 years although these have not yet been used extensively in smallholder storage. There is some field experience with hermetic grain bags and in the case of PICS bags the observation that in cowpea storage in Niger 79% of bags were in use at the end of the third year indicates that an assumption of at least 2 years life span would be reasonable. In the case of GrainPro SuperGrainbags®, field data suggests a 1-2 year useful life. Claims for other types of hermetic bags that are not yet backed up by lengthy field testing must at this stage be regarded as aspirational. The larger hermetic stores using heavy PVC covers (GrainSafe®, Grain Cocoon®) apparently have long life spans (10-15 years) provided they are not subject to rodent attack, although in that case some repair is possible. All the metal containers are attributed life spans of at least 20 years provided they are maintained well, and in particular are kept off damp floors that would lead to corrosion. Plastic drums/silos, concrete silos and a range of larger conventional store types (improved brick stores, improved baskets etc.) all have potential lives of up to 20 years but again dependent on good maintenance.

When stores have reached the end of their life they can no longer be used for their intended purpose but they may retain some residual value. In the case of hermetic bags they may still be used for conventional storage but could also find a myriad of domestic uses including plastic ropes and mats, rain-shedding wearables, baby diaper covers, roofing, storage of clothing, as window covers, etc.. Plastic drums and silos may also be turned into conventional stores once their hermetic seal is lost or pressed into use as water tanks. Metal structures offer some recompense as scrap and may also find use as water tanks. Concrete and mud silos and larger conventional store types have found use as poultry houses.

Table D1. Overview of life spans and any residual value of different store types

HERMETIC BAGS	PICS bag	<p>Life span - In Niger, when cowpea is stored in PICS bags 79% of bags were in use at the end of the third year; usage declines fairly sharply thereafter.</p> <p>Residual value - Storage of crops not requiring hermetic storage, making plastic ropes and mats, rain-shedding wearables, baby diaper covers, as roofing, storage of clothing, as window covers.</p>
	GrainPro SuperGrainbag®	<p>Life span 2-3 harvests (Uganda), 2 years (Zimbabwe), 1 +year (Kenya), however in Vietnam a seed producer had used bags we had sold for 6 seasons with a seasonal loss of around 8% due to poor handling, damage. Depends on rodent and LGB attack. In Kenya the IV-R variant is still susceptible to LGB attack</p> <p>Residual value Once punctured can be used in 'ordinary grain storage' (i.e. not hermetic). Finds other uses in patching leaking roofs (Kenya), and as containers to hold captured crickets (Cambodia).</p>

	Bio-Plastics triple bag	<p>Life span In practice 2 to 4 years; partly due to rodent attacks, cuts by old carting trucks and excessive exposure to sun. Under ideal conditions - 7 years.</p> <p>Residual value - NA</p>
	AgroZ Agrobag® & Agrobag plus®	<p>Life span - 3 years</p> <p>Residual value - NA</p>
HERMETIC COCOONS	GrainPro cocoon®	<p>Life span Come with 5 year warranty, but life depends very much on how well they are maintained. Could easily last 10 years. Damage by rats, cigarette holes etc. But there are repair kits so small holes can be sealed.</p> <p>Residual value - NA</p>
	GrainPro GrainSafe II®	<p>Life span - 10-15+ years. Rats can chew through it if not positioned properly or during storage of the empty container</p> <p>Residual value - Roofing, tarps</p>
OPEN-WEAVE BAGS	Polypropylene bag	<p>Life span - Depends on initial quality and handling - 1 - 2 years. Frequent handling by traders reduces lifespan, also may be holed by rodents and rough storage structures, and holed by pests such LGB or <i>Rhizopertha</i>.</p> <p>Residual value - In Kenya/Tanzania - 1) transporting maize cobs or cassava or sweetpotato back from the field if not too badly holed, 2) Flooring in house or mats to sit on outside house, 3) Curtains across bathroom doors etc.</p>
	Jute sack	<p>Life span - 2 years (Ghana). Handling practice and rodents are issues in longevity</p> <p>Residual value - NA</p>
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	<p>Life span Manufacturer says 2 years but other independent evidence is lacking. 2 years based on active life of insecticide. Dependent on handling and possibly also climate.</p> <p>Residual value - Probably as an ordinary bag for grain storage.</p>
METAL CONTAINERS	Metal silos	<p>Life span 15 to 20 ±5 years, depending on management including provision of shade, pallet and avoidance of contact with moisture. All depends on conformity to installation and management recommendation. Common malpractices include placing heavy objects on the silo, poor installation (placing the silo on an uneven platform, on the floor and exposure to water and sunshine). Extension messages advocating proper installation can be accessed using an Airtel mobile phone SMS facility called 321</p> <p>Residual value - Water tanks, scrap metal</p>
	Metal tanks	<p>Life span Typically 15 to 20 years but if installed outside so exposed to the elements then about 10 years.</p> <p>Residual value - Scrap metal</p>

	Metal drums	<p>Life span Certainly 25 years, their durability is one of the attractions. Durability improved by placing the drum on a stand of wood or brick so the base doesn't have contact with moist ground. Not likely to be much variation as they are very robust.</p> <p>Residual value - Scrap metal</p>
	CONCRETE SILOS	<p>Life span Given reasonable maintenance will last 10 to 15 years. Variations due poor roofing of the structure and infestation of construction materials by borers such as LGB and lesser grain borer. Other causes of variation may be due to poor construction standards, e.g. messing around with the recommended sand to cement ratio and improper mixture of sand and cement.</p> <p>Residual value None, except that in some instances the structure may be used to house poultry.</p>
	MUD SILOS	<p>Life span Quite variable depending on type of mud silo and prevailing climate, although usually only used in the drier climates. With good maintenance in some case could be 10-15 years, but could be longer in particularly dry locations. A thatch covering to protect against rainfall will prolong life. Variability depends upon the exposure to termite attack, rainwater, rats and quality of material used for construction.</p> <p>Residual value - Chicken coop, fire wood but normally just demolished</p>
	PLASTIC SILOS	<p>Life span 15-20 yrs</p> <p>Residual value - water tank, non-hermetic store</p>
	OTHER IMPROVED STORES	<p>Improved brick granary with compartments</p> <p>Life span - 0-25 yrs. Models constructed at the Institute of Agricultural Engineering in 1993/4 are still functional. Life-span depends on constant and adequate roof cover with eaves extended to protect the granary walls.</p> <p>Residual value - NA</p>
	Improved woven basket granary (kihenge)	<p>Life span The improved traditional structure can be used for up to 10 years depending on good.</p> <p>Residual value - NA</p>
	Improved farmer granary	<p>Life span Depends on farmers care</p> <p>Residual value - NA</p>
	Gorongosa mud granary	<p>Life span – Likely to be 10-15 years, if well maintained</p> <p>Residual value - NA</p>

E. Marketing and promotion campaigns

Information was collected on whether each of the improved store types which the respondents were familiar with had been the subject of marketing or promotion campaigns. If they had, further information was collected on when, where, what form the campaigns took, whether they had included any practical type training, and whether they had been successful. This information is summarised in Table E1.

In general the responses suggest that there have been significant resources invested in marketing and promoting some of the improved store types (e.g. PICS bags, metal silos). However, there has been very little, if any, formal evaluation of comparatively how successful or cost effective these promotion approaches are. As several of the store types have only come onto the market in recent years, it may be premature to judge the success of their marketing campaigns, as agricultural behaviour change often takes a while.

Polypropylene bags are the most widely used store type across Sub-Saharan Africa (SSA). Their usage has spread rapidly and increased over time without major investments in product promotion.

Practical training on how to use the store, principles of its design and mode of action and in some cases how to construct it is seen as an important aspect of product marketing and promotion.

Table E1 Overview of marketing and promotion campaigns for different store types

HERMETIC BAGS	PICS bag	<p>Numerous PICS bag marketing campaigns in 20 different African countries as well as Afghanistan and Nepal, have been organised by the PICS project teams from 2007 onwards.</p> <p>Since 2007: Senegal, Mali, Burkina Faso, Ghana, Togo, Benin, Nigeria, Niger, Chad, and Cameroon.</p> <p>Since 2012: Afghanistan</p> <p>Since 2013: Rwanda, Kenya, Nepal, Burundi, and D.R. Congo</p> <p>Since 2014: Tanzania, Uganda, Ethiopia, Malawi, and Zambia</p> <p>Since 2015: Sierra Leone.</p> <p>These marketing or promotion campaigns used a wide range of approaches including: village or market place demonstrations during or just prior to the harvest season, posters, leaflets, banners, cell phone videos, radio spots, TV spots, newspaper articles, drama, community radio training, agricultural exhibitions and events such as food safety week, or launch ceremonies by Ministers of Agriculture.</p> <p>They have been further promoted through their inclusion in collaborative on-farm storage trials by researchers, extension agents and farmers.</p> <p>Most felt it was too early to judge whether these promotion approaches have been successful. Some feel the campaigns lack a long-term sustained promotion strategy, and that the distribution network is the problem. Others feel adoption is now beginning to pick up.</p> <p>These marketing campaigns have been accompanied by training of trainers and farmer training.</p> <p>Trainers were trained in a 2 day ToT event. This covered the major 'do's and don'ts' of PICS bag use, and explained the mode of action</p>
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and taught them how to answer typical questions that arise.

The trainers then conducted village training activities in each focal village. Trainers implemented 1 to 2 hour demonstrations to teach farmers how to use PICS bags. Grain was loaded into PICS bags by pilot farmers, then the bags were then stored for 4 to 6 months, after which 'open-the bag' public events were organized (and sometimes televised) to assess the effectiveness of the technology in preventing losses.

In some locations the training/demonstration session included: review of storage pests of major crops; management methods of stored products; the use of PICS bags to address post-harvest losses (demonstration); mode of action of PICS bags; efficacy of PICS bags for grain and seed storage; assessing grain quality during storage; the economics of the PICS bags (cost: benefit analysis).

In Rwanda training was reported to target agro-dealers as well as trainers and farmers.

GrainPro SuperGrainbag®	Since 2004, they have been promoted through IRRIs rice, maize and coffee storage activities. There has been wider promotion by GrainPro but they have not provided details.
	Zimbabwe: 2014 onwards (through development agents) Uganda: Mar 2014-May 2015 (during WFP storage trials)
	No M&E of the promotion campaigns has been done, so there is limited understanding of how successful promotions have been.
	The marketing or promotion has been through: demonstrations at shows, farmer meetings and other agricultural events but is not felt to be sufficient to break into the smallholder market where the greatest demand is likely to be.
	In Uganda, with a 70% subsidy by WFP, 31,872 SuperGrainbags were distributed (in bundles of 4 per farmer).
	Most demonstrations have been accompanied by some training. When initially launched, IRRI did a lot of practical training of first adopters and NARES partners. Including on: safe storage conditions, grain – surrounding air relationships, MC, how to set up a cocoon, how to seal it and to check that it is sealed, principle of hermetic storage, how to measure moisture content.
	In WFP's recent Ugandan storage trials and promotions, a 1 day training workshop covered improved post-harvest management techniques and practical applications of new handling and storage equipment. This was followed-up by on-farm refresher training and correct positioning of the new household storage technologies.
Bio-Plastics triple bag	Marketing campaigns were reported to have started in 2011, with a focus on 3 West African countries.
	Ghana: 2011 to 2013 (mainly by NGOs in collaboration with MoFA e.g. Concern Universal, FARA, SATTIFS project) Nigeria: 2011 to 2014 Cameroon: 2012

		<p>Successful promotion campaigns in Northern and middle belt of Ghana were considered to include: radio adverts, focus group discussions at the community level involving agricultural extension agents, and Durbars (leaders events).</p> <p>Training (~2 hours) had involved demonstrations on: how to use the bags and minimise the air in them, and how to avoid damage/punctures to them.</p> <p>Demonstration trials were set-up and grain was stored in the bags, which were then opened 6 months later during a community open-day.</p>
	AgroZ Agrobag® & AgroZ Agrobag plus®	The Agrobag products are soon to be launched onto the East African market, and no marketing or promotion of them has yet occurred.
HERMETIC COCOONS	GrainPro cocoon®	<p>There have been worldwide marketing campaigns by GrainPro. In Zimbabwe, they have occurred since 2014.</p> <p>Sales are reported to have increased annually, although no figures were shared.</p> <p>As for the Grain SuperGrainbags, IRRI did a lot of training of first adopters and NARES partners. GrainPro now provides their own training (via practical demonstrations of ~3hrs), but at a limited scale. The IRRI training included: safe storage conditions, grain – surrounding air relationships, moisture content, how to set up a cocoon, how to seal it and to check that it is sealed, principles of hermetic storage, and how to measure moisture content.</p>
	GrainPro GrainSafe II®	Reported to have not yet been actively marketed.
OPEN-WEAVE BAGS	Polypropylene bag	<p>Polypropylene (PP) bags are widely marketed and used throughout most African countries. This has occurred without the need for specific marketing campaigns.</p> <p>The supply chain is typically strongly developed, and in most countries they are readily available at local markets at village level during the harvest season.</p> <p>In Zimbabwe it is reported to be mandatory to use UV stabilised PP bags when the grain will be delivered to a strategic grain reserve or warehouse receipt system programme.</p> <p>Most postharvest training inadvertently refers to or demonstrates the use of PP bags (including how to admix grain protectants, load grain into PP bags, close and sew up PP bags, carefully stack PP bags on pallets away from walls, monitoring of grain stocks), as they are so commonly in grain storage.</p>
	Jute sack	No marketing activities were reported.
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	<p>Marketing/promotion has to date occurred in several states of Nigeria and Ghana and through Government food security programmes. The product has not yet completed the registration process in other African countries.</p> <p>It is too premature to judge the success of the marketing campaigns.</p>

METAL CONTAINERS	Metal silos	<p>The distribution channels have been trained on the appropriate way of using the technology to ensure that only non-infested grains are stored in the bags.</p> <p>Demonstrations were done to show the powerful killing action which occurs when insect pests touch the sides of the bags.</p> <p>Metal silos have been the focus on numerous promotional campaigns across Africa in recent years (see below), and Central America since 1990s.</p> <p>Malawi: A number of campaigns including the launch by the President in April 2007. Metal silos mounted on floats during Independence Celebrations (2008 - 2011), displayed during the National Agricultural Fairs (2007-2014), displayed in Agricultural Shows at national, Agricultural Development division and district levels (2007- 2014), Farmer field days and open days (2007-2014)</p> <p>Zimbabwe: 2010 to date Zambia: 2007 to date Kenya: 2012-2014 Uganda: Mar 2014-May 2015 (through WFP) Tanzania: (years not specified)</p>
<p>The metal silos project teams often say the campaigns have been very successful. Others say less so or not successful, as they argue real uptake of the silo is low due to its high cost. Many silos are distributed or subsidised by projects, but it is pointed out that this is neither a sustainable uptake pathway for the silo nor a realistic indicator of adoption or promotion campaign success.</p> <p>Promotion campaigns have included: field days, training sessions, media (radio), agricultural fairs, demonstrations, training of artisans, setting up demos/pilots sometimes followed by field days or discussion days, exhibits at public gatherings such as provincial or national agricultural shows and trade fairs.</p> <p>WFP distributed 3,652 metal silos in Uganda while subsidising their cost by 70%.</p> <p>Training has featured in the promotion campaigns, including: Demonstration of proper use of metal silos (~30 mins).</p> <p>Training local artisans in the fabrication of metal silos (typically a 5 day training during which they each construct a full-size metal silo from scratch and learn about postharvest losses). A training manual for local artisans has been developed (Kenya, Zimbabwe, Malawi).</p> <p>In Malawi some reported that too much emphasis was put on local fabrication and distribution of metal silos and not on training of extension services in the proper utilisation of the technology. More recently CIMMYT has trained front line staff, agro-dealers, and lead farmers and as a result adoption has increased in Mchinji and Lilongwe.</p>		
<p>Extension training in Zimbabwe took 3-5 days, involving a field visit to</p>		

	<p>a site where the silo was being used, demonstrating the silo model and visiting the workshops at IAE.</p> <p>In Uganda WFP organised a 1 day training on improved post-harvest management techniques and practical applications of new handling and storage equipment. This was followed up with on-farm refresher training and correct positioning of new storage technologies.</p>
Metal tanks	<p>There has been no active marketing campaign, but through extension officers the government has encouraged the purchase and usage of these metal tanks. The extension officers conducted practical training on the use of the metal tanks.</p> <p>Promotion appears to have been successful as the metal tanks are used throughout the Swaziland and in rodent management project areas of Bangladesh; though no formal study has been done.</p>
Metal drums	<p>Metal drums have been promoted in East Timor – since 2010 by ‘Drums on Farms’ and CARE, plus other NGOs such as: Mercy Corps, CRS, World Vision, Hivos, Trocare, Oxfam. Concern and Child Fund switched from supplying metal silos to metal drums.</p> <p>The campaigns were successful but the NGOs could not provide enough drums to meet demand.</p> <p>Drums on Farms used direct extension advice to poor highland farmers growing new higher yielding maize varieties.</p> <p>Metal drum for storage use was demonstrated in villages, building on the successful introduction by the Indonesians some years before. No instruction leaflet or stickers on the drum summarising how to use it were supplied, but the drums were numbered.</p>
CONCRETE SILOS	<p>Promoted in Malawi since the 1990s following the introduction of LGB.</p> <p>Promoted through demonstrations, training (farmers and extensionists), media, agricultural shows and fairs, field days, and floats – actively 2005-2012. But efforts are considered unsuccessful as adoption remains very low.</p> <p>District crop protection officers were trained (5 day course) to be trainers in the construction and management of the concrete silos. But they did not disseminate the knowledge and skills to front line staff and farmers which lead to poor performance of the structures.</p> <p>The training covered: management of stored grain, stored product pests, pest control, construction of the concrete silo. Training included practical work and demonstration.</p>
MUD SILOS	<p>Improved mud silos were promoted across the Sub-Saharan Africa (SSA) region in FAO projects during the 80s and 90s, mainly following the introduction of LGB (e.g. Malawi, northern Ghana).</p> <p>In Mozambique an elevated traditional mud silo has been promoted on a small scale by Min of Ag; and the Tethere silo promoted as part of a seed bank system by Helvetas in Northern Mozambique 2008-2012.</p>

		<p>Promotions were done through demonstrations; training of farmers, extension agents and media; and talks.</p> <p>Mud silos were partially adopted, in southern Benin this was when farmers were informed by extension agents, produced large quantities of maize and/or had severe storage problems and they typically modify the stores to fit their situation (see Adegbola & Gardebroek, 2007). In Malawi mud silo adoption was very low, in northern Ghana it was higher.</p> <p>Trainings focused on mud silo construction, postharvest management and use. They typically included the physical construction of a mud silo (e.g. Malawi, Ghana, Mozambique). Some programmes also set up exchanges for technology providers between different areas.</p>
PLASTIC DRUMS /SILOS		<p>In most countries the plastic silo has not been promoted.</p> <p>In Tanzania plastic containers are used as stores but have not been promoted or marketed via campaigns. In Kenya, the Kentainer water tank is being trialled as a store. In Uganda, plastic tanks were included in a 1 day WFP training and in trials from Mar 2014- May2015, and 6,142 of them distributed when a 70% price subsidy was offered. In Bangladesh, a rodent management project promoted it during a practical 2 day training of 15,000 farmers from 2002-2006.</p>
OTHER IMPROVED STORES	Improved brick granary with compartments	<p>Improved brick granaries have been promoted erratically throughout Zimbabwe by Government Departments and NGOs. The NGOs typically built them for target households, while the Government usually erected one to serve as a model and nucleus of technology dissemination.</p> <p>Training took 2 forms.</p> <ol style="list-style-type: none"> 1. Hands-on training of builders in the target sites. The builders would then be expected to serve other customers along business lines. 2. Training of extension officers and mechanisation technicians on grain postharvest management. The training would be similar to that of the metal silos. <p>No adoption studies have been done.</p>
	Improved woven basket granary (kihenge)	<p>Promotional activities for improved traditional (<i>kihenge</i>) woven baskets typically involved demonstration stores in Tanzania.</p>
	Improved farmer granary	<p>These improvements to farmers' granary's were promoted in Cambodia through project activities in 6 provinces (10 villages in each). Improvements to local stores are considered the most popular postharvest interventions.</p> <p>Training involved hands-on activities, and the IRRI quality kit to create awareness on stored produce quality.</p>
	Gorongosa mud granary	<p>In 2000 – 2001, there was a campaign in Gorongosa and Cheringoma districts of Sofala Province of Mozambique supported by the Ministry of Agriculture and GTZ. Progress was hampered by the centralized nature of the dissemination strategy. In light of this experience it was</p>

concluded that there should be 1) an information campaign to ensure that households know the benefits of the silos, 2) the creation of a 'Granary promoter' with technical skills combining both silos construction and good storage management, and 3) a system for access to credit to assist adoption. In 2006 the campaign was extended to all districts of Sofala. There have been further campaigns by World Vision and CARE and in 2009 a Joint UN Programme (FAO, IFAD, WFP) within which FAO assisted in the replacement of traditional maize cob storage with Gorongosa granaries and metal silos.

F. Extent of adoption of different store types and the features affecting it

An overview of grain storage experts' views of the extent of adoption of different store types is provided in Table F1. There have been very few adoption studies of improved stores. Few respondents provided numbers or locations relevant to store type adoption, suggesting most of the responses on the extent of adoption were fairly anecdotal. Where store types have only recently been introduced, they are facing challenges in setting up the supply/distribution chain to reach farmers in a wide geographical area at local level.

Polypropylene bags are currently used for grain storage by >80% of smallholder farmers in Malawi, Tanzania, Kenya and Zimbabwe (and probably many other countries in SSA), as well as being used as packaging in most of the larger scale grain trade, strategic food reserves and millers.

A long list of features that made particular store types preferable to others, and the weaknesses of each store type were provided by respondents, these are shown in Tables F2 and F3.

Key features leading to adoption of stores are perceived to include: the initial investment level (as low as possible); the durability; the efficacy of the store in preventing insect and rodent damage to grain; the ability to store grain without having to add pesticides; ease of use and flexibility of capacity.

These same aspects were reflected in the weaknesses of each store type, and additionally the need to strengthen distribution networks for some store types in order to make them more easily available at local level.

F1. Extent of adoption of store types

Table F1 Overview of grain storage experts' views on the extent of adoption of different store types

HERMETIC BAGS	PICS bag	<p>Despite all the promotion, PICS bags adoption was not felt to be wide spread yet. Some felt an adoption study was needed to be able to answer this point.</p> <p>The PICS project team reported that 4.5 million PICS bags have been produced and sold by plastics manufacturers and input dealers in SSA, and the PICS bag market is now expanding into Asia. Initially in West Africa, the PICS project helped distributors finance PICS bag orders, but by 2010 the distribution system was entirely in the hands of African entrepreneurs (Moussa <i>et al.</i>, 2014).</p> <p>Lack of availability of PICS bags at local level was viewed as a constraint to adoption; as where it was available locally it was being adopted. An adoption study in ten countries in West and Central Africa, found 46% of respondents had stored some cowpea at least once in potentially hermetic containers (e.g. double bags, triple bag, plastic jerry cans, metal drums) between 2008-2011 (Moussa <i>et al.</i>, 2014). Living in a village where a PICS demonstration had occurred was the strongest factor influencing adoption of PICS bags. 34% of respondents living in PICS demonstration villages had at least once stored some of their cowpea in a PICS bag. The most common reason for not using the PICS bags was their local unavailability at the relevant time of year. Another recent study which interviewed 2,741 women in Burkina Faso, Niger and Nigeria found 46% of women had used PICS bags to store their cowpeas (Ibro <i>et al.</i>, 2014).</p>
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	GrainPro SuperGrainbag®	Adoption is currently low, setting up the last mile delivery supply chain is challenging. Margins are extremely low, and a distributor might only sell a few bags to each farmer. In Zimbabwe it was only introduced in 2014 (to farmers in 10 districts). Anecdotal information suggests it is doing well in coffee storage in Ethiopia. In Uganda, WFP provided it at 70% subsidised rate and distributed 31,872 bags across the four regions of Tororo, Soroti, Gulu and Mbarara. Regional sales figures were not provided.
	Bioplastics triple bag	It is being promoted mainly in the Brong Ahafo, Northern, Upper East and Upper West Regions of Ghana and seems to be quite widely adopted where cereals and pulses are commonly grown.
	AgroZ Agrobag® & AgroZ Agrobag plus®	Hermetic bags are not widely used in East Africa. Awareness will have to be raised and demand created. This is likely to be a lengthy and expensive process requiring donor support.
HERMETIC COCOONS	GrainPro cocoon®	In most countries it has been mostly adopted by the industry and distributed through government programs. First adopters are seed producers, but it is also used for commercial grain.
	GrainPro GrainSafe II®	This is a new product.
OPEN-WEAVE BAGS	Polypropylene bag	Polypropylene (PP) bag usage is very high. Estimates suggest the following % of smallholder farmers use it: Malawi: 90% Tanzania: 80% (but ~70% use it improperly, fewer farmers now use traditional granaries due to ease of PP bag storage) Kenya: 100% Zimbabwe: >80% (in Zim the UV resistant PP is also being marketed, elsewhere it is just the normal PP bag) A lot of larger scale traders and strategic food reserves store produce in PP bags inside warehouses.
	Jute sack	~/~
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	This a new product which has completed registration in several West African countries where marketing has started. Registration is on-going in other countries, and the product roll out will start this year (2015).
METAL CONTAINERS	Metal silo	Despite the significant amount of promotion of metal silos, it appears that no comprehensive adoption study has yet been done. Respondents suggest the following extent of adoption. Tanzania: adoption is still very low as it is new Kenya: very limited, mainly in Western and Eastern Malawi: not widely adopted due to high initial costs but wealthy peri-urban farmers adopt them. 500 silos have been made by artisans Rwanda: only adopted in project target districts Zimbabwe: adoption is very limited. Uganda: 3,652 metal silos distributed by WFP at 70% subsidised rate in Tororo, Soroti, Gulu and Mbarara

Myanmar: seen but often not used anymore	
Metal tank	<p>15,000 farmers were trained and are reported to be using the metal tanks in Comilla, Nertokona, Kustia, Bogra and Satkhira districts of Bangladesh.</p> <p>Metal tanks are widely used widely throughout Swaziland by maize growers who can afford it. Numbers are not known.</p>
Metal drum	<p>In East Timor, 379 (1 drum/HH) were purchased by farmers during the Drums on Farms project; and 3,000 (2 drums/ HH) during the CARE project. More were distributed by other NGOs but no numbers available.</p> <p>There has also been adoption of metal drums in Senegal for cowpeas (CRSP project, Purdue), and they are used for maize storage around Arusha area of Tanzania.</p>
CONCRETE SILOS	<p>Adoption remains low even among farmers who got silos free-of-charge as demonstration materials. Most of the silos have been abandoned due to insect infestation occurring after the pesticide stopped being effective.</p> <p>FIDP (Farm Income Diversification Programme) constructed 1,500 silos in Mzimba, Rumphi, Lilongwe, Chiradzulu, Dowa and Thyolo districts of Malawi. In peri-urban areas a few farmers paid the full price for the concrete silo. Another estimate suggest 2.5% of farmers countrywide use the concrete silos.</p>
MUD SILOS	<p>Malawi: ~5% of farmers countrywide use mudded granaries.</p> <p>Ghana: most farming HHs in northern Ghana have one.</p> <p>Mozambique: elevated silo – study ongoing.</p> <p>Mozambique: Tethere seed bank silo, wasn't adopted outside of project, and many of the silos got abandoned.</p>
PLASTIC DRUMS/ SILOS	<p>Kenya: no adoption of the Kentainer yet as it is new as a store</p> <p>Tanzania: not much adoption yet</p> <p>Uganda: 6,142 plastic tanks were distributed (@70% subsidy) across Tororo, Soroti, Gulu, Mbarara</p> <p>Bangladesh: Most of the 15,000 farmers trained in rat management are using the plastic silo.</p>
OTHER IMPROVED STORES	<p>Improved brick granary with compartments</p> <p>No study has been done to determine the extent of adoption.</p> <hr/> <p>Improved woven granary (<i>kihenge</i>)</p> <p>~/~</p> <hr/> <p>Improved farmer granary</p> <p>Although the improved farmer granary in Cambodia is perceived to have huge potential, it is often overlooked for promotion as it is neither a research product, nor complex and 'sexy' and easily marketable.</p> <hr/> <p>Gorongosa</p> <p>In the period up to 2006 only about 400 granaries were constructed.</p>

mud granary In 2011 WFP's P4P project trained 114 farmers to construct silos and facilitated the construction of 569 Gorongosa granaries and 370 metal silos, (Annual Report for Mozambique, 2011).

F2. Reasons for adoption: features that make this store type preferable to others

Table F2. Positive features of the different store types

STORE TYPE ▽	Polypropylene bag	Jute sack	ZeroFly® storage bag	PICS triple bag	Bio-Plastics triple bag	Agrobags®	GrainPro SuperGarin bag®	GrainPro GrainSafe II®	GrainPro cocoon®	Metal silos	Metal tanks	Metal drums	Concrete silos	Mud silos	Plastic silos/drums	Improved brick granary	Improved kihenge	Improved farmer granary	Gorongosa mud granary
	▽ Positive features of store (as mentioned by respondents)																		
<i>Too early to comment</i>			X		X	X	X												
Low initial investment	X		X	X	X	X	X			X	X			X	X		X	X	X
Durable (lifespan of >7 years)								X	X	X	X	X	X	X	X	X	X	X	X
Insect control without chemical pesticides*				X	X	X	X	X	X	X		X			X				
Easy to use	X	X		X	X	X	X				X				X				
Robust and resistant to fire										X	X	X		X					X
Rodent proof										X	X	X		X					
Choice of different capacity sizes								X	X	X	X		X	X	X	X	X	X	X
Convenient and portable in case it suddenly needs to be moved for sale or due to flood	X	X	X	X	X	X	X												
Easily adaptable to the quantity of grain to be stored, and location	X	X	X	X	X	X	X												
Easy to keep in house & protect from theft	X	X	X	X	X	X	X			X		X			X		X		
Easy to fumigate grain inside it								X	X	X	X								
User-friendly for women	X	X		X	X	X	X			X					X				X
Can be locally made in a rural area										X				X		X	X	X	X
Relatively difficult to remove grain thus easy to control consumption & 'unwanted removals'												X		X	X				
Often given out for free										X									
Occupies a small space										X									
Easily hidden during food shortages	X	X	X	X	X	X	X												
Powerful killing action of any insects that touch the walls of the bag			X																
Multi-purpose packaging (transportation, handling and storage)	X	X	X	X	X	X	X												
Easy to monitor for insect damage	X	X	X	X	X	X	X												
Easy to calculate amount of grain in stock	X	X	X	X	X	X	X												
Standard measurement for uniform packing, stacking, sampling, commodity accounting etc.	X	X	X	X	X	X	X												
Formal market trading unit (when filled)	X	X																	
Easily available locally, even at village level	X																		
Wide adoption, good supply chain efficiency	X																		
UV resistant PP bags do not become brittle	X																		
Anti-slip weaving helps in stacking	X	X	X	X	X	X	X												
Bag does not break during quality sampling	X	X	X																
No harvest of natural resources each year	X	X	X	X	X	X	X			X		X			X				
Status symbol for farmers				X	X	X	X			X									

Key: X= respondents suggestions on specific store types, X = authors' overview of other store types affected by same issue

*= Viewed as positive as i) farmers prefer not to use pesticides on their food; ii) eliminates health risks and other MRL issues such as import rejection; iii) less need to wash grain pre milling; iv) no additional cost of purchasing insecticide

F3. Weaknesses of the store type

Table F3. Weaknesses of the different store types

Weaknesses of this store ▽	STORE TYPE ▽																		
	Polypropylene bag	Jute sack	ZeroFly® storage bag	PICS bag triple bags	Bio-Plastics triple bag	Agrobags®	GrainPro SuperGarin bag®	GrainPro Grain safe II®	GrainPro Grain cocoon®	Metal silos	Metal tanks	Metal drums	Concrete silos	Mud silos	Plastic drums/silos	Improved brick granary	Improved kihenge	Improved farmer granary	Gorongosa mud granary
<i>Too early to comment</i>			X			X													
Susceptible to rodents and rough handling	X	X	X	X	X	X	X		X						X				
Prone to termite damage		X												X					
Prone to insect attack	X	X																	
May not withstand typical handling methods*				X	X	X	X												
Capacity/ size is often limiting												X			X				
Distribution network needs strengthening			X	X	X	X	X			X						X			
Care required each time during closing			X	X	X	X	X	X	X	X	X	X			X				
Must be kept closed for a period to generate hermetic effect, before grain can be removed				X	X	X	X	X	X	X	X	X			X				
Must be full so that volume of oxygen is low, so drum size must match quantity to be stored										X	X	X			X				
Grain being stored must be below 14% mc	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Knowledge intensive technology			X	X	X	X	X	X	X	X	X	X			X				
Environmental concern -short lifespan/ plastic				X		X	X												
Labour intensive									X										
Zipper is weakest point and needs regular checking to prevent entry of oxygen									X										
Hard to set-up, instructions are poorly written								X											
Only protects clean non-infested grain			X																X
Insect infestations in the grain bulk continue to develop during storage if no pesticide added	X	X	X										X	X		X	X	X	X
Stored grain requires regular monitoring	X	X								X	X	X	X	X	X	X	X	X	X
Requires a pallet to keep them off the ground	X	X	X	X	X	X	X			X	X	X							
Needs thorough cleaning out if acquired as second hand fuel container												X							
Handle with care during transport/ needs roof										X			X	X					
Difficult to install in houses with small doors										X									
Not hermetic, some farmers fumigate it indoors										X									
Often hard to seal in/outlets to make hermetic										X	X								
Quality control challenges for handmade silos										X	X								
Loading &/or off-loading grain can be difficult										X		X				X			
Stored grain may be affected by ambient moisture	X	X											X	X			X	X	
Not easily movable to a new place													X	X		X	X	X	X

Key: X= respondents suggestions on specific store types, X = authors' overview of other store types affected by same issue, ?= No evidence yet. *= Typical handling, e.g. being thrown when full on ground during unloading or piled high on trucks.

G. Barriers to adoption of different grain store types and suggestions for overcoming them

A large number of barriers to adoption of grain stores were mentioned, many of them cross-cutting such as: perceived high cost of store; poor awareness of and technical knowledge with regards to the proper usage of the store resulting in it underperforming; low availability of the store at local level as supply chain not well developed yet; poor efficacy against rodent, LGB and other storage insect pests or termite damage (Table G1).

Suggestions for overcoming these barriers include: improving postharvest knowledge and skills of different stakeholders in the innovation systems; supply chain development; improving the technical efficacy of some grain storage solutions; developing financial services to support postharvest loss reduction; developing a more enabling environment through policy and market changes; increasing donor support for postharvest loss reduction (Table G2).

Table G1. Main barriers to adoption of each store type

Main barriers to adoption of this store ▽	STORE TYPE ▽																		
	Polypropylene bag	Jute sack	ZeroFly® storage bag	PICS bag triple	Bio-Pastics triple bag	Agrobags®	GrainPro SuperGarin bag®	GrainPro GrainSafe II®	GrainPro Grain cocoon®	Metal silos	Metal tanks	Metal drums	Concrete silos	Mud silos	Plastic drums/silos	Improved brick granary	Improved kihenge	Improved farmer granary	Gorongosa mud granary
Initial cost too high			X			?	X	X	X	X	X				X	X			
Limited local availability at right time, supply chain not developed yet	X ¹		X	X	X	X	X			X									
Poor awareness/ technical knowledge on use ²			X	X	X	X	X	X	X										X
Limited lifespan due to rodent, Larger Grain Borer or termite	X		?	X	X	?	X						X	X					
Lack of marketing activities							X	X											
Grain theft fears when structure is outside								X	X	X	X		X	X		X	X	X	
Inadequate training and publicity campaigns					X														
Price vs durability too high for smallholders			?	X	X	?	X												
Needs to be purchased, can't be self-made	X	X	X	X	X	X	X	X	X	X	X	X			X				
National systems want locally produced solutions								X	X						X				
Too big for farm level storage ³									X										
Lack of credit facilities at harvest time ⁴						X													
Complex to set-up								X											
Registration constraint ⁵			X																
Additional cost of treating grain with pesticides	X	X											X	X	X	X	X	X	X
None, hence why it is so widely adopted	X																		
Projects don't like idea of old oil drums, or relative difficulty of grain removal ⁶												X							
May need a shelter built to accommodate it										X									X
Are they really cost effective?										X									
Crop storage not a priority for agric. extension										X				X		X	X	X	
Trained artisans do not have capital to start enterprise, especially if demand not certain										X									
Deficient supply chain of inputs/ materials										X									
Lack of skills for constructing mud/clay store in cylindrical shape. Particularly for women.													X						
Bigger stores need wood that's becoming rare													X						
It may not be considered modern or urban													X						
Communal management of seed banks had problems													X						
Only one size																X			
Kentainers not very interested in this market															X				
Difficult to change mind-set of farmers from using a water storage container to store grain															X				
Only one inlet/outlet point at the top of barrel															X				
Problems coordinating building time/builders availability with farmers resources/timing																X			

Key: X= respondents suggestions on specific store types, X = authors' overview of other store types affected by same issue, ?= No evidence yet. ¹=In some rural areas of Mozambique, supply and access to PP bags is reported to be an issue. Everywhere else they are said to be very easily available. ²= Some users not able to differentiate between hermetic bag and non-hermetic bag which is only a fraction of the price. ³= Cannot take out small amounts of grain without disturbing naturally produced modified atmosphere. ⁴=Problem as farmers' need to raise cash at harvest time (when grain prices are low) together with expected postharvest losses which act as a disincentive to storing grain on-farm. ⁵= in some countries the ZeroFly bag registration process takes a long time due to the insecticide incorporated in the bag. ⁶=by contrast the users find the relatively difficult of grain removal as a plus as it reduces unwanted withdrawals.

Table G2. Suggestions for overcoming barriers to adoption of improved stores

Improved postharvest knowledge and skills
<ul style="list-style-type: none"> • Inclusion of postharvest management and different store types in the normal extension service delivery to farmers, work with government to change some extension messages and guidelines.
<ul style="list-style-type: none"> • Increased publicity and capacity building of users through regular training.
<ul style="list-style-type: none"> • Increased awareness raising of postharvest issues and storage options through: radio programmes; TV, cell phone videos, presentations at conferences; more village level technology demonstrations; training local leaders on use of technology (e.g. how to tie & store PICS bags); promotional material that includes evidence of satisfied users; more aggressive marketing by local manufacturers; campaigns to agro-dealers prior to harvest time to ensure the bags are available at harvesting.
<ul style="list-style-type: none"> • Improved training for farmers and other stakeholders on ensuring: they only load clean dry grain into stores/sacks; the room they are going to place the store/sack in is clean; sacks are stacked on pallets without touching the walls; regular monitoring; and that any grain to be stored for >3 months in a non-hermetic container is treated with a protectant. To improve the success of crop storage.
<ul style="list-style-type: none"> • Improve awareness and skills on applying correct pesticide dose and observing the withholding periods (between pesticide application and consumption of grain) and cleaning the grain by winnowing to remove pesticides to reduce food safety risks.
<ul style="list-style-type: none"> • More training on hermetic storage, advantages and cost. Encourage youth to attend training as they may better understand the science behind hermetic conditions.
<ul style="list-style-type: none"> • Support farmer groups to use hermetic cocoons.
<ul style="list-style-type: none"> • More training in agri-business/market-based approaches, value chain systems, technical postharvest aspects.
<ul style="list-style-type: none"> • Use refresher trainings to update staff on postharvest issues
Supply chain development
<ul style="list-style-type: none"> • Support for production of novel store types, and supply and distribution chains to make them widely available at the appropriate time (e.g. harvest) of year at the local level (via input shops etc.).
<ul style="list-style-type: none"> • Supply chain development: Engage more private sector actors to increase sales retail points in rural areas; piggyback on cell phone card system for distribution network; build postharvest knowledge of supply chain actors; need for input credit system; reduce import and domestic tax on postharvest loss reduction materials, and increase demand to reduce the cost of importation.
Technical efficacy of grain storage solutions
<ul style="list-style-type: none"> • Improve the storage technologies to make them more effective, e.g. redesign metal silo outlet port to facilitate easy sealing (note rubber tubing is becoming scarcer as more vehicles use tubeless tyres); add steel mountings to the base which can be fixed into concrete to sector the silo; promote metals silos not only as a hermetic store, but also to use in combination with a grain protectant; construct silos inside the dwelling house to improve security and reduce theft risks.
Financial services for improved postharvest management
<ul style="list-style-type: none"> • Access to finance: Help farmers to form groups or associations in order to ease access to loans to cover the costs of grain storage solutions; SACCO could buy hermetic bags in bulk and distribute to members at a lower cost; Creation of merry-go-round savings schemes or revolving funds to loan to farmers to purchase improved stores as an agricultural input; Group fundraising to help cover the costs of a granary or other postharvest equipment.
<ul style="list-style-type: none"> • Provision of credit facilities by designated rural banks and microfinance institutions.
Enabling environment
<ul style="list-style-type: none"> • More structured grain trade and quality standards.
<ul style="list-style-type: none"> • Government subsidies which can be used for postharvest loss reduction technologies.
Donor support for postharvest loss reduction
<ul style="list-style-type: none"> • Donors, NGOs and CBOs could finance the purchase of hermetic bags or silos to support the most vulnerable so that they can store food throughout the year. Some donors are doing this.
<ul style="list-style-type: none"> • Set up more donor funded market-pull programmes such as AgResults.

H. Smallholder farmer access to credit facilities for postharvest storage

No respondents reported credit that was specifically available to smallholders for addressing postharvest losses. However, various local level savings and lending groups are being supported amongst rural communities, which would enable members to access credit to use at their discretion for priority agricultural activities such as improved grain storage (Table H1). Several respondents felt that low cost storage solutions should not require smallholders to engage in complicated credit arrangements, as they should be within the budgetary means of most smallholder households particularly if their use brought high returns.

Some of the heavily donor supported technologies such as PICS bags and metal silos reported interacting with formal and informal financial services to help raise awareness about the importance of postharvest inputs as well as pre-harvest inputs.

Some grain storage technologies were reported to have been heavily subsidised by donors, which was seen by many experts to be both unsustainable and preventing in-depth understanding of the major economic barriers to adoption.

Table H1. Smallholder access to credit facilities for different grain store types

HERMETIC BAGS	PICS bag	<p>Most smallholders do not have access to credit facilities to help them adopt this store type.</p> <p>Some smallholders are organised into Village Savings and Lending type groups where they generate funds from their contributions and start to provide credit which can help access such technologies</p> <p>Some smallholders are able to cash purchase PICS bags</p> <p>In Tanzania the PICS project is working with NMB to include PICS bags as an input to be loaned to farmers, and with an agrodealer to provide loans to farmers for PICS bags.</p> <p>In Rwanda, no particular arrangements have been made but farmers can access loans at local banks and via SACCO.</p> <p>In West Africa, anecdotal information suggests that inventory storage programs are starting to provide loans based on cowpea in storage in hermetic bags, as lenders have confidence that their collateral will be safe (Moussa <i>et al.</i>, 2014).</p>
	GrainPro SuperGrain bag®	<p>Smallholders should be able to purchase these without credit.</p> <p>WFP is exploring this avenue further for future expansion of activities.</p> <p>In most locations no credit for purchasing this hermetic bag was available to smallholders.</p>
	Bio-Plastics triple bag	<p>Microfinance companies and Concern Universal offered credit which could cover the whole cost of the bag, if farmers used the money for this.</p>
	AgroZ Agrobag® & AgroZ Agrobag plus®	<p>Credit for small holders is very limited and usually only available to farmers with adequate collateral</p>
HERMETIC COCOONS	GrainPro cocoon®	<p>The cocoon is too large for smallholder use, but could be used by farmer groups or cooperatives. Groups usually have better access to credit than individuals.</p>

		In Zimbabwe no credit arrangements have accompanied the use of this store yet.
	GrainPro Grain safe II®	No
OPEN-WEAVE BAGS	Polypropylene bag	PP bags are not viewed as very expensive by rural households, and are typically reused a couple of times. Credit for smallholders is very limited and usually only available to farmers with adequate collateral. In Zimbabwe, farmers who deliver grain in the UV resistant PP bags get refunded 75% of its cost.
	Jute sack	No
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	Too early
METAL CONTAINERS	Metal silo	No formal institution is supporting farmers to acquire storage facilities. WFP is exploring the formal credit avenue to expand its storage activities. Financial institutions in Kenya have tailored credit facilities which could be used by groups to purchase metal silos. Projects are typically promoting saving and lending farmers' groups.
	Metal tank	No credit to date, but local NGOs could provide credit to smallholders
	Metal drum	No
CONCRETE SILOS		No
MUD SILOS		No
PLASTIC DRUMS/ SILOS		In most countries no credit facilities for adopting plastic silos exist. In Uganda: WFP is exploring credit avenues to expand storage equipment access activities. In Tanzania, farmers' saving and lending groups (VICOBA) are sources of finance for farmers to acquire storage facilities.
OTHER IMPROVED STORES	Improved brick granary with compartments	No
	Improved woven basket granary (kihenge)	No
	Improved farmer granary	No
	Gorongosa mud granary	The plan after 2006 was to have credit facilities as part of adoption campaigns but currently there is no information on this.

I. Use by institutions or at community scale

Several of the store types are reportedly being used for grain storage by community grain banks and schools (Table I1). However, the scale of use by these stakeholders is not clear, and none of the respondents appeared to have data on this.

Table I1. Use of different grain store types by institutional or community level organisations

		Schools/ Orphanages	Community Grain Banks	Relief organisations	National Food Reserves	Large Warehouses	Agro-processors/ Millers	Traders/ Transporters	Hospitals/Prisons/Military	Seed companies/ prods.	Comments
HERMETIC BAGS	PICS bag	X	X	X							No estimate of numbers. Procurement procedures for public schools, hospitals, military centres and prisons are often very bureaucratic which hinders use of PICS bags by them although.
	GrainPro SuperGrainbag®		X			X				X	By seed producers all over SE Asia. Especially for storing smaller amounts of high quality seeds.
	Bio-Plastics triple bag	X	X								At low level currently. In Upper west region and Brong-Ahafo regions of Ghana
	AgroZ Agrobags®										
HERMETIC COCOONS	GrainPro cocoon®		X								Would be ideal for relief organisations.
	GrainPro GrainSafe II®		X								NGOs have bought and given to farmers
OPEN-WEAVE BAGS	Polypropylene bag	X	X	X	X	X	X	X	X		Used throughout all the countries and by everybody who handles grain in formal channels, plus by most who store grain at HH level. Institutions may store more than 1000 PP bags of grain
	Jute sack										
INSECTICIDE TREATED BAGS	ZeroFly® storage bag										Company expects it to be ideal for large warehouses, institutions, seed companies and relief organisations. Stacking and anti-slip as per PP
METAL CONTAINERS	Metal silos	X	X	X					X		In most countries numbers are not available. A total of 11 of 2.5-3t capacity in 4 provinces of Zimbabwe, 6 x 1t in 2 provinces (Boarding schools)
	Metal tanks		X				X		X		Numbers not known, but commonly used by institutional players throughout Swaziland
	Metal drums										Capacity and offloading difficulties make them less suitable for large scale operations
CONCRETE SILOS			X								Mostly in Northern Malawi, numbers not known as a number of players involved in their construction.
MUD SILOS			X							X	Usually used by individual smallholder HHs. Used for community grain storage in all 3 Northern regions of Ghana and villages in southern Ghana.
PLASTIC DRUMS/ SILOS											None, due to the small size of most plastic silos.

OTHER IMPROVED STORES	Improved brick granary with compartments	X	X									Social welfare uses under “Zunde RaMambo” scheme which targets the less privileged in society e.g. orphans. It is coordinated by traditional leaders.
	Improved woven basket											None.
	Improved farmer granary											Not known
	Gorongosa mud granary											Intended specifically as a household store.

J. Advice on usage

Several of the newer and heavily-donor supported store types such as hermetic bags and metal silos, have the instructions for use printed or stuck onto the product (Table J1). Instructions for these products are also typically available in several different local languages and in poster or leaflet formats. There are also a number of short (<5 mins) youtube videos online demonstrating how to use PICS bags in a range of different African languages.

Postharvest training manuals tend to cover the recommended use of a range of different store types including the most popularly used ones (e.g. the woven polypropylene bag).

Suggestions for improving the instructions included, adding more information about necessary treatment of grain prior to storage, e.g. how to dry grain to a safe storage moisture content, sorting grain, avoiding cross contamination with infested grain. For hermetic bags and stores, additional information was also suggested on: explaining that the container needs to be kept sealed at start of storage period for a sufficient length of time to achieve the modified atmosphere and kill the developing insect stages; and the need to fill hermetic drums and silos in order to help reduce the amount of oxygen in the container. Translation of instructions into a wider range of vernaculars was suggested. Many of the instructions use excellent graphical images of the different stages which helps in reducing the need for translation into multiple languages.

Table J1. Overview of instructions for use of the different store types

	Are there instructions?	Are instructions complete, if not what should be added or changed?	Copy sent?
HERMETIC BAGS	<p>Instructions are printed on the PICS bags in some countries.</p> <p>There are also several well-illustrated (drawings showing local people obtaining, loading grain and sealing the PICS bag) extension leaflets available online in a wide range of local languages.</p> <p>http://www.entm.purdue.edu/PICS2/poster_download.php</p> <p>Several short youtube videos exist on how to use PICS bags Malawi English</p>	<p>The available instructions are generally considered good.</p> <p>But could be improved by: i) ensuring information about pre-conditions for storing the grain well, e.g grain drying to safe storage moisture content and grain sorting, are added into all versions</p> <p>ii) vernacular translation of on-bag instructions could improve use (although adds complexity where several main languages used in a</p>	Yes

		<p>https://www.youtube.com/watch?v=fW3nLOzUDBs Niger</p> <p>https://www.youtube.com/watch?v=GifT44oXzpM</p> <p>A protocol for storage trials with PICS bags was also sent.</p>	country).	
	GrainPro SuperGrainbag®	<p>Instructions with pictures and in local languages are printed on the bag. There are also videos produced by IRRI.</p> <p>GrainPro has instruction sheet and a business case fact sheet.</p>	Instructions in some locations still need translating into vernacular.	No
	Bio-Plastics triple bag	Instructions are printed on the bags.	Considered complete.	No
	AgroZ Agrobag® & AgroZ Agrobag plus®	<p>The Agrobag instructions for use are available on request to potential buyers and will be available for wider use once currently planned initiatives in East Africa are launched. Interested parties should apply directly to A To Z Textile Mills Limited.</p>	<p>Current instructions (series of photo steps demonstrating bag use by a Tanzanian lady) will be modified in light of user experience and feedback. They do not currently emphasise the importance of only storing grain dried to below 13% mc (safe storage limits).</p>	No
HERMETIC COCOONS	GrainPro cocoon®	<p>See GrainPro operators manual supplied with the product.</p> <p>Related videos or IRRI training manuals are available through the Rice Knowledge Bank which describes the cocoon and shows images of it, explains how it works but does not provide instructions for setting it up and using it.</p> <p>http://www.knowledgebank.ir/ri.org/step-by-step-production/postharvest/storage/cocoon</p>	Need to be adjusted to local conditions/ language	No
	GrainPro GrainSafe II®	<p>One user was aware of hard copy instructions supplied with the product.</p> <p>IRRI fact sheet shows photo of the store plus advantages and disadvantages.</p>	There are pages of instructions in small print in English, no pictures. They are not easy to follow and should be re done.	No
OPEN-WEAVE	Polypropylene bag	In most countries, no grain storage instructions for use	The WFP Improved Grain Storage Training Manual	Yes

BAGS		with PP bags are sold with the bags (NB PP bags are generic and used for the storage of many commodities including fresh vegetables, fertiliser etc)	covers many of the important steps of use of PP bags, and how to treat grain to be stored in PP bags long term, and how to stack and monitor PP bags in households and warehouses.	
	Jute sack	~/~		No
INSECTICID E TREATED BAGS	ZeroFly® storage bag	Instructions not on product. 24 page product brochure sent by company. Company explains that it should only be used with clean uninfested grain, otherwise a pre-treatment or fumigation after bagging is required to ensure pest free grain.	No. User instructions don't accompany product.	Yes
METAL CONTAINERS	Metal silos	Instructions on how to use a metal silo exist. In some locations there are sticker style instructions attached to the metal silo. In others posters in local language. In other locations there are no written instructions just a 1 day training for farmers to help them choose the storage option that best fits their need.	Some feel the instructions are complete Others suggest they should add: <ul style="list-style-type: none"> • A section stating what additional items need to be built • A section emphasising the need for dry grain to be used • Inclusion of the type of rubber tubing to be used for sealing the store when filled • More emphasis on how the hermetic conditions work in preserving grain quality There is still a need for demonstration sites An extension agents booklet on silo usage and management is needed.	Yes
	Metal tanks	None as the tank is not commercially manufactured	No. Basic safe storage in metal tank instructions need to be developed.	No

	Metal drums	Manual giving background on use of metal drums, advantages of metal drums, discussion of: i) risks re contamination with fuel, ii) unloading narrow, iii) cleaning out of drums and aflatoxin risk. Instructions for drum storage.	Yes	Yes
	CONCRETE SILOS	No documented extension guides or instructions on use of concrete silo exist.	No	No
	MUD SILOS	<p>Various Instructions for constructing and/or using a mud silo exist from different countries and organisations. (e.g. the elevated mud silo and tethered silo in Mozambique, FAO manual)</p> <p>Ghana mud silo instructions:</p> <ol style="list-style-type: none"> 1. Do not construct structure under trees 2. Do not construct on a water way, preferred location is up land 3. Cover the structure with thatch during rainy season, whether empty or with grains 4. Plaster structure with mud after every storage season both inside and outside. 5. Provide light heat to kill insects in the structure from the previous season by burning dried grass inside it. 	Need for better instructions on how to construct a mud silo.	Yes
	PLASTIC DRUMS /SILOS	<p>In most countries no instructions on plastic silo use are available.</p> <p>In Uganda, WFP has hard-copy instructions on plastic silo use which were given to beneficiary farmers in their recent trials and subsidised promotion of stores.</p>	No	No
	OTHER IMPROVED STORES	Improved brick granary with compartments	No	No
		Improved woven basket granary	No	No

(kihenge)			
Improved farmer granary	A fact sheet that explains how to improve granaries in English and in Khmer	Probably not complete	Yes
Gorongosa mud granary	Written instructions are not available but were probably produced for the promotion projects.	Not known	No

K. Experts subjective views of the different store types

For most store types there was at least one respondent who indicated a preferred feature; dislikes were less frequent.

Open weave bags are seen as ideal for grain marketing and the requirement for an insecticide treatment if grain is to be retained for longer periods of storage is seen as both an advantage, since it is relatively easy to do at the time of bagging, but also a disadvantage compared with the use of hermetic bags (PICS, SuperGrainbags® etc.) or grain bags that have insecticide incorporated into their fibres (ZeroFly®).

A frequently voiced advantage of hermetic/fully sealed store types was that they generate a modified atmosphere that is lethal to insect pests which obviates the need for insecticide treatment. Not mentioned, but clearly an advantage, is that three of the four listed hermetic grain bags are now produced locally in Africa. On the negative side, their vulnerability to rodent, and possibly also insect, attack that could damage the airtight seal is seen as a drawback. Not mentioned was the need to keep the hermetic bags closed during the period that the modified atmosphere is being generated, some four to six weeks. Presumably this is not perceived as a problem since only grain for longer term storage would be placed in such bags.

Metal drums, tanks and silos have several features that make them popular. They are robust and resistant to rodent and insect damage and other sources of puncture, giving them long life spans. In the case of silos and tanks they can be constructed by local artisans. Drums could easily be produced locally using relatively low cost machinery if so required but there is a second hand market in fuel drums that are suitable if thoroughly cleaned. The disadvantage of tanks and silos is that they are not always easy to make fully airtight, especially if the seams have soldering faults and the inlet and outlet ports are worn. While metal drums are easy to make gastight. For tanks and silos the high initial costs is a disadvantage but their long lives give low costs per unit stored when spread over many years; especially true for the larger (and relatively cheaper) models. Metal drums tend to be relatively low cost, especially if second hand, however their availability may be limited.

Plastic drums are appreciated as being relatively cheap and a more robust store than grain bags. Mud and concrete silos are effective but neither is fumigable so pest control would rely on insecticide admixture. The same is true of the larger improved granaries but they do offer large capacity and the brick built Zimbabwean design provides compartments for the storage of different grain types.

Table K1. Overview of the opinions of experts on different store types

<p>HERMETIC BAGS PICS bag</p>	<p>Like - Rwanda - Can keep the grain longer than in the case of insecticidal treatment and the grain is healthy for human consumption. The bags can be kept inside the house. Kenya - The two different layers of plastic provide greater insect deterrents. It is simple to use. General - The PICS bag is easy to use, convenient and does not require the use of chemicals. The technology is scale neutral- e.g. a 100kg bag capacity can effectively store 20 kg without any losses. Large quantities of grain can be stored using PICS bags (OPVN Niger stored 80,000 tons of cowpea in PICS bags). Also, the technology can be locally manufactured in most developing countries where there are plastic manufacturers.</p> <p>Dislike -Zimbabwe - The current version is too big compared to</p>
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		<p>what the farmers are used to (50kg). If used by farmers to full capacity, handling might be a problem because of the weight. Prone to LGB damage and possible rodent damage rendering the technology non-hermetic. Rwanda - It requires technical know-how. Cannot be used on large stores, piling bags over others might be difficult. Quality control of bags at manufacture company cannot be guaranteed, if they are not high density, then insects can enter inside or create holes.</p>
	GrainPro SuperGrainbag®	<p>Like - Hermetic, controls moisture and insects without pesticides, compared to household metal silos cheap, protected from theft since stored in house (but this reduces living space).</p> <p>Dislike - Weak so limited lifespan, prone to LGB damage and possible rodent damage rendering the technology non-hermetic. Inability to repair after being damaged, not easily reusable. Need for distribution network, not based on being able to construct oneself; need for purchase. Environmental disposal issues. The tie cable provided can tear the bag.</p>
	Bio-Plastics triple bag	Like - Easy to use, cost effective
	AgroZ Agrobag® & Agrobag plus®	Like - Control (by asphyxiation and dehydration) of all storage pests including LGB. Allegedly resistant to LGB penetration either the inside or outside. Very affordable cost compared with metal or plastic silos and metal drums.
HERMETIC COCOONS	GrainPro cocoon®	<p>Like - Relatively cheap, no pesticides, flexible use...</p> <p>Dislike -Not certain if it can survive LGB and rodent attack from outside</p>
	GrainPro GrainSafe II®	Dislike -Setting it up is very complex and instructions are poor.
OPEN-WEAVE BAGS	Polypropylene bag	<p>Like - Low cost so easily accessible to smallholder farmers. The grain is kept in a presentable state, ready for transport, handling, storage and marketing, improves sampling and accounting. Can easily be combined with insecticide admixture to extend storage period.</p> <p>Dislike - Short lifespan of the bags, variability of product quality, susceptibility to rodent attack, need for insecticide treatment for longer storage periods.</p>
	Jute sack	Dislike - They are very prone to agents of grain loss such as weevils, larger grain borer, lesser grain borer, rodents and even moisture (if placed in structures not protected from rains).
INSECTICIDE TREATED BAGS	ZeroFly® storage bag	Like - Insects killed on contact with the bag, grain can be consumed exactly when required and bag can be reused, no handling of pesticide and negligible insecticide residues on grain.
METAL CONTAINERS	Metal silos	Like - Very durable and can be produced locally so creating employment. Cost benefit analysis suggests it is cheap compared

		<p>with other stores. Re-cycling is easier than with plastic. Can be made airtight, so avoids use of insecticides. The metals walls are smooth and hygiene is easy to maintain. It is proof against insect pests, rodents and ambient moisture and temperature (if instructions to keep it under complete shade are adhered to). Deals with rodents and insects (including LGB) effectively without use of pesticides.</p> <p>Dislike - At household level keeping them airtight is not easy and becomes more difficult with the larger silo sizes. The initial cost of silos is high for farmers and as they need to be located in the shade either inside the house or in a special shelter, this adds to the costs. Once a silo is constructed within a house it is very difficult to transfer it to another place through the main door. The grain near the silo bottom is not easy to withdraw, unless someone gets into the silo. Quality control is difficult. It is difficult to source raw materials on a consistent basis. There is a shortage of artisans in farming regions for silo construction.</p>
	Metal tanks	Like - Robust, rodent-proof and easily fumigated
	Metal drums	<p>Like - Low cost, hermetic, robust, and very popular with its users.</p> <p>Dislike - Nothing to dislike. However, it may not suit all circumstances.</p>
CONCRETE SILOS		Dislike - It is not proofed against storage pests and so must use insecticide admixture to protect the grain. Re-treatment is required after 12 months (effective period for storage pesticides). This requires offloading and reloading of the silo which is tedious and labour demanding.
MUD SILOS		<p>Like - Materials for construction are easily available. Can be used for the storage of grain both before and after threshing. Moderate cost.</p> <p>Dislike - Not airtight and not gas-tight enough for a successful fumigation. Prone to attack by rats and termites. Needs maintenance, low security so only practical in rural areas</p>
PLASTIC DRUMS/ SILOS		Like - More durable than SuperGrainbags®, and less expensive than metal silos, and readily available on the market. Are good for storage of those crops which are commonly stored in small quantities. e.g. pulses. Easily moved.
OTHER IMPROVED STORES	Improved brick granary with compartments	<p>Like - Durable. An adaptation of traditional granaries. Reduces LGB problem if combined with an effective pesticide. The multi-compartment nature enables farmers to store different types of grain under one roof, grain budgeting or allocation for different purposes or to different people.</p> <p>Dislike - Frequent re-thatching is required and sometimes the thatch grass may not be easily available because of veld fires or drought.</p>

Improved woven basket granary (kihenge)	Dislike - By storing in the improved traditional structures there is an additional cost for packing in bags if required for marketing.
Improved farmer granary	Like - Low cost, can be community activity, can be done with locally available materials Dislike - Water absorption during the wet season, insects not controlled.
Gorongosa mud granary	Like - Better alternative to wood built stores as does not require scare food and is fireproof. Also more secure against theft and less easy access to pests Dislike - No evidence that it can be fumigated successfully; not possible to relocated it once constructed

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Annex 1 – Storage options survey form

Survey of Grain Store Options

Grain stores survey. This survey focuses on those types of store that development organisations could promote as components of loss reduction campaigns. We would like to document your experience, your thoughts and your opinion on these storage solutions, using the questionnaire on the next page.

Recently, in developing countries there has been renewed interest in reducing the postharvest losses of cereals and grain legumes (pulses). Consequently, several new designs of grain store are being promoted, especially in Sub-Saharan Africa.

We are contacting you because we believe you may be able to help us with important information about grain stores. Our interest is especially in those types of store that development organisations could promote as components of loss reduction campaigns.

Despite the long-term interest in small scale storage, there is no convenient place where practitioners can go for advice on different types of grain store. Some years ago, we published a table comparing store types in the WFP ‘Training Manual for Improving Grain Postharvest Handling and Storage’ (see image below).

SECTION 2 - HOW TO GET HIGH QUALITY GRAIN ON FARM

Table 2.2: Comparison of store types for safe storage of grain in smallholder households

Store type	Storage Period	Pest Control	Weaknesses	Costs US\$/kg	Life Span	Cost/tonne/year
Open weave sacks (jute, sisal, polypropylene) 	0-6 months	If >3 months storage then admix insecticide (Section 5.13.1). For cowpea an option is to use solarisation if this is not for seed (Section 5.13.3)	If used >6 months, grain quality declines more rapidly than in other store types	0.1t unit US\$ 0.03	3 years	US\$10 (+ pest control costs)
Improved mud silos 			Shorter life than metal silo, very heavy so can't be moved to new location, takes up fixed space in house whether empty or full	1t unit US\$0.1/kg	5 years	US\$20 (+ pest control costs)
Metal silos 		1. Make hermetic then use lighted candle or phosphine fumigation, or 2. Admix insecticide (Section 5.13.1)	Extra sealing required to make hermetic, then no access for 2 weeks.	0.18t unit = US\$0.41/kg 1.8t unit US\$0.18/kg	15 years	US\$27.4 (+ pest control costs) US\$12.4 (+pest control costs)
Polythene bags (1 liner + sack)	3-12 months	1. Solarisation if grain not for seed	Best for small quantities. susceptible to	0.05t unit US\$0.045/kg	2 years	US\$22.5

This table works well but now we need something more accessible and more easily updated. To do this we are designing a web resource that give details of different store types and allows easy comparisons so the most appropriate store for a particular situation can be selected. These pages will appear on two websites; FAO's [Community of Practice on Food Loss Reduction](#) and also NRI's [Postharvest Loss Reduction Centre](#).

We would be very grateful if you could complete the questionnaire below for those grain stores types for which you have experience. When completed please return forms to Rick Hodges (R.J.Hodges@gre.ac.uk) and Tanya Stathers (T.E.Stathers@gre.ac.uk). We hope to have all the questionnaires returned to us by 9th March 2015. If you would like your contribution acknowledged then put a cross [x] in the box at the end of the questionnaire. Otherwise responses will remain anonymous. This work is being undertaken in association with the Swiss Agency for Development and Co-operation.

The Grain Store Questionnaire

Below there is a separate questionnaire form for each grain store type. There are two such forms below. If you would like to complete forms for more than two store types then please make copies of the form and paste them in at the end of this document.

For any clarification or assistance with the questionnaire please contact Tanya Stathers

T.E.Stathers@gre.ac.uk

Name of respondent:

Job title:

Institutional affiliation:

E-mail address:

Store type 1

A. General description of the store	
1. Put a cross [X] against the type of grain store for which you are submitting information. In addition, type in the name of the store alongside the store type. For example, '[X] Hermetic grain bag: name PICS bag'	<input type="checkbox"/> Open weave bag: name ... <input type="checkbox"/> Insecticide impregnated bag: name ... <input type="checkbox"/> Metal silo: name ... <input type="checkbox"/> Metal drum: name ... <input type="checkbox"/> Plastic silo: name ... <input type="checkbox"/> Mud silo: name... <input type="checkbox"/> Hermetic grain bag: name ... <input type="checkbox"/> Other type: name ...
2. What weight of grain can this store type hold or what volume is it? If available in multiple sizes then please indicate each.	
3. Which grain types are stored (indicate the different types of cereal grain or pulses). If possible indicate differences by country and the different frequencies with which the different grains are stored.	
B. Construction & manufacture	
4. From what materials is the grain store constructed?	
5. Whereabouts is the store manufactured and who manufactures it?	
C. Costs of store	
6. Please list examples of the full price cost of the store to the end user. This will presumably vary by country and by market. Please indicate currency, country, market and year.	
7. If subsidies have been applied to the cost of this store by governments, NGOs or projects then what % of the total cost has been subsidised in each country?	

8. If certain elements of the store construction materials are subject to government concessions such as reliefs on taxes etc. then please give details	
D. Lifespan of store	
9. For how long will the store remain fully serviceable as intended by the manufacturer (years)?	
10. How much variation is there in the 'normal' lifespan? If there is variation then please comment on the causes.	
11. What uses are there for worn or damaged stores?	
E. Marketing campaigns	
12. Has this store type been subject to marketing campaigns and promotions? Please list countries and dates.	
13. Were the campaigns and promotions considered successful? What form did they take?	
14. Was any training included in the marketing campaigns and promotions? If 'yes' then how long did they last (hours) and what subjects were covered? Did the training involve practical work, or a demonstration of how to use the store?	
F. Extent of adoption	
15. In the country (ies) where you work, how widely adopted is this store type. Indicate the degree of geographical spread and where known the numbers of adopters.	
16. For those who have adopted this store type, are there any particular features that make it preferable to other store types?	
17. What are the weaknesses of this store type, in comparison to other store types?	
G. Barriers to adoption	
18. What do you consider to be the main barriers to adoption of this store type? This could include technical, financial and social issues.	
19. If you can suggest ways that these barriers can be overcome please list them.	

H. Credit facilities	
20. Have smallholders had access to credit facilities to help them adopt this store type. If 'yes' then who has provided these loan facilities, and typically what proportion of the total cost has the loan covered.	
I. Use in community or institutions	
21. Besides use by smallholders, please list any situations where the store type is used by institutions e.g. schools, hospitals, military, prisons, in community grain storage, or by relief organisations etc.	
22. If the store is being used in any of the ways listed in Q21. then please add any additional information such as numbers of stores, geographical location etc.	
J. Advice on usage	
23. Are there instructions on how this store type is used? If 'yes' then would you please forward us a copy when you return the questionnaire. Alternatively indicate where we could obtain the instructions.	
24. If there are instructions do you consider that they are complete? If you do not, please indicate what should be added or changed.	
K. Your subjective views of this store type	
25. What do you particularly like about this store type that makes it preferable to other stores?	
26. What do you particularly dislike about this store type?	
27. Can you add, with relevant details, any other points about this store type which we have not specifically asked about, but you feel are important?	

[] Put a 'x' here if you would like your contribution acknowledged on the 'Storage Options' webpage.

Name of respondent:

Store type 2

A. General description of the store	
1. Put a cross [X] against the type of grain store for which you are submitting information. In addition, type in the name of the store alongside the store type. For example, '[X] Hermetic grain bag: name PICS bag'	<input type="checkbox"/> Open weave bag: name ... <input type="checkbox"/> Insecticide impregnated bag: name ... <input type="checkbox"/> Metal silo: name ... <input type="checkbox"/> Metal drum: name ... <input type="checkbox"/> Plastic silo: name ... <input type="checkbox"/> Mud silo: name... <input type="checkbox"/> Hermetic grain bag: name ... <input type="checkbox"/> Other type: name ...
2. What weight of grain can this store type hold or what volume is it? If available in multiple sizes then please indicate each.	
3. Which grain types are stored (indicate the different types of cereal grain or pulses). If possible indicate differences by country and the different frequencies with which the different grains are stored.	
B. Construction & manufacture	
4. From what materials is the grain store constructed?	
5. Whereabouts is the store manufactured and who manufactures it?	
C. Costs of store	
6. Please list examples of the full price cost of the store to the end user. This will presumably vary by country and by market. Please indicate currency, country, market and year.	
7. If subsidies have been applied to the cost of this store by governments, NGOs or projects then what % of the total cost has been subsidised in each country?	

8. If certain elements of the store construction materials are subject to government concessions such as reliefs on taxes etc. then please give details	
D. Lifespan of store	
9. For how long will the store remain fully serviceable as intended by the manufacturer (years)?	
10. How much variation is there in the 'normal' lifespan? If there is variation then please comment on the causes.	
11. What uses are there for worn or damaged stores?	
E. Marketing campaigns	
12. Has this store type been subject to marketing campaigns and promotions? Please list countries and dates.	
13. Were the campaigns and promotions considered successful? What form did they take?	
14. Was any training included in the marketing campaigns and promotions? If 'yes' then how long did they last (hours) and what subjects were covered? Did the training involve practical work, or a demonstration of how to use the store?	
F. Extent of adoption	
15. In the country (ies) where you work, how widely adopted is this store type. Indicate the degree of geographical spread and where known the numbers of adopters.	
16. For those who have adopted this store type, are there any particular features that make it preferable to other store types?	
17. What are the weaknesses of this store type, in comparison to other store types?	

G. Barriers to adoption	
18. What do you consider to be the main barriers to adoption of this store type? This could include technical, financial and social issues.	
19. If you can suggest ways that these barriers can be overcome please list them.	
H. Credit facilities	
20. Have smallholders had access to credit facilities to help them adopt this store type. If 'yes' then who has provided these loan facilities, and typically what proportion of the total cost has the loan covered.	
I. Use in community or institutions	
21. Besides use by smallholders, please list any situations where the store type is used by institutions e.g. schools, hospitals, military, prisons, in community grain storage, or by relief organisations etc.	
22. If the store is being used in any of the ways listed in Q21. then please add any additional information such as numbers of stores, geographical location etc.	
J. Advice on usage	
23. Are there instructions on how this store type is used? If 'yes' then would you please forward us a copy when you return the questionnaire. Alternatively indicate where we could obtain the instructions.	
24. If there are instructions do you consider that they are complete? If you do not, please indicate what should be added or changed.	
K. Your subjective views of this store type	
25. What do you particularly like about this store type that makes it	

preferable to other stores?	
26. What do you particularly dislike about this store type?	
27. Can you add, with relevant details, any other points about this store type which we have not specifically asked about, but you feel are important?	

[] Put a 'x' here if you would like your contribution acknowledged on the 'Storage Options' webpage.

More copies of the questionnaire form can be copied and pasted in here for further store types

Annex 2 – List of survey respondents

The authors of this report gratefully acknowledge the support of the 24 people listed below, for sharing their experience of grain stores by completing one or more questionnaires during the course of this survey. Five other respondents wished to remain anonymous.

Contributor	Affiliation
Bernadette Majebelle	Pee Pee Ltd, Tanzania
Brighton Mvumi	University of Zimbabwe, Zimbabwe
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Fuseini Haruna Andan	Ministry of Food and Agriculture, Ghana
Hippolyte Affognon	International Centre for Insect Physiology and Ecology, Kenya
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James Mwangi Ndiritu	Vestergaard Group S.A, Switzerland
Kimondo Mutambuki	Kenya Agricultural and Livestock Research Organisation, Kenya
Larry Murdoch	Purdue University, USA
Marko Mbilinyi	HELVETAS Swiss Intercooperation, Tanzania
Martin Gummert	International Rice Research Institute, The Philippines
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Samuel Addo	Ho Polytechnic, Ghana
Sophie Walker	ACDI/VOCA, Kenya
Suraj Devani	Pee Pee Ltd Tanzania
Tahirou Abdoulaye	International Institute of Tropical Agriculture
Tanya Stathers	Natural Resources Institute, University of Greenwich, UK