3R Kenya Project Practice Brief 003

Private and public costs & benefits of implementing a quality based milk payment system in Kenya

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3R Robust Reliable Resilient From Aid to Trade

Background

Assuring the quality and safety* of milk and dairy products has been a persistent problem in the Kenyan dairy sector, caught between limited consumer awareness on quality & safety, processors and traders competition for milk volumes neglecting quality, poor milk handling practices along the chain, and lack of enforcement of quality & safety regulations. This has led to a situation in which safety of dairy products cannot be guaranteed. Milk quality is important to the consumer in terms of taste and flavour attributes and its potential impact on health (Bernadette, 2008). The per capita milk consumption in Kenya is increasing over the years and its per capita consumption of milk is projected to reach 220 kg by 2030 (DMP 2010). While this increase may improve nutritional outcomes, concerns with poor milk safety would mean increased exposure of consumers to health risks.

Increased attention is recently being paid on milk quality and safety of dairy products in Kenya by industry actors. With better milk quality and safety consumers are less exposed to related illnesses which would reduce or avoid costs imposed on the health care system. Milk quality is also important to processors and food companies due to it impacts on product yields, taste, consistency and shelf life, thus affecting profit margins and (local and export) market access (Caswell, 1998). This is evidenced by the quality based milk payment systems (QBMPS) piloted by a few processors, that take into account food safety parameters in addition to others.

*In this study, "**Milk quality** refers to a combination of characteristics that enhance the acceptability of the milk product. Quality relates to chemical, physical, technological, bacteriological and aesthetic characteristics of milk and milk products" (Makerere University, 2018; page 5).

Key messages:

In cash terms, the farmer is the greatest beneficiary of a well-functioning QBMPS. His profit is about 2 KES/kg milk if he produces Grade A milk.

The QBMPS also enables farmers to benefit from social inclusion, chain integration and productivity gains leading to business sustainability.

The CBE (Collection and Bulking Enterprise) and processor have a net additional cost (difference between costs and benefits) totalling 2.5 KES/kg milk, mainly driven by the huge initial costs for laboratory equipment, additional staffing and training of farmers.

Regarding public health, we estimate an annual loss of 53,000 healthy life years (Disability Adjusted Life Years) translating to about 850 full lives annually in Kenya due to milk-related infectious diseases.

With a modest commitment of farmers, the QBMPS can generate health benefits of about 10 KES/kg milk as avoided health costs from milk related illnesses.

These enormous public health benefits justify public and donor investments to support in setting up the QBMPS, especially to subsidise costs of the CBEs and processors, until the QBMPS can finance them.

1. Introduction

1.1 General Introduction

Consumption of poor quality & unsafe milk is known to be hazardous in various ways. a) It may contain foodborne pathogens which can cause several diseases with various effects on humans (Tegegne and Tesfaye 2017; Fernandez et al 2017; Oliver et al 2005). b) Uncontrolled and high use of antibiotics may cause allergic reactions and antibiotics resistance, which can harm public health in the long term (Ahlberg et al., 2016; Darwish et al., 2013). c) The presence of aflatoxins in milk, which in Kenya originates mainly from poorly stored or preserved concentrates and forages, has been shown to cause cancer and fertility problems in consumers (Mutiga et al., 2015; Peng and Chen, 2009). d) Abusive use of hydrogen peroxide, a milk preservative that is banned in Kenya, can cause irritation of the gastrointestinal and respiratory tracts showing various symptoms that could lead to a coma and even death (Watt et al., 2004).

Quality based milk payment systems (QBMPS) have been successfully used in controlling and improving milk quality along the dairy chain (Pašić et al. 2016; Garcia Botaro et al, 2013). In order to produce good quality and safe dairy products, all actors along the dairy chain have an important role to play; input providers have to comply with standards, such as producing aflatoxin-free feed; dairy producers need to source inputs from approved suppliers and improve animal husbandry and milk handling practices; cooperatives need to minimize collection time and install cooling facilities, build laboratory facilities for milk testing, and train milk graders; processors need to invest in laboratory facilities and staff as well as in trainings and extension, regulators need to enforce the respect of quality standards along the chain, just to name a few. This implies that there are many actors involved in a QBMPS supply chain. Each player incurs various costs and/or accrues various benefits, some of which are private (business) and others public good* in nature. The number and combination of quality parameters in a QBMPS may vary from country to country and from processor to processor, depending on the policies in place and the needs and ambitions of the actors. This study uses the model of Happy Cow ltd as a pilot to introduce a QBMPS in Kenya that integrates smallholders as suppliers in their business model.

**Public goods are defined as goods that are non-rivalry in consumption and non-excludable. This means that one person's consumption does not affect another person's opportunity to consume the good, and their consumers cannot deny each other the opportunity to consume the good. Healthcare is considered a public good because treating patients reduces their likelihood of spreading diseases. Good healthcare reduces the chance of getting sick during office/school hours and doesn't deprive anyone else from benefit of reduced risk of disease; people can't deny each other the benefits of their better health (Inge et al. 1999; Illingworth and Parmet 2015).*

What is a Quality Based Milk Payment System?

In a Quality Based Milk Payment System, payment for milk is not only based on volume, but also on a number of quality standards, be they microbial and/or physicochemical. The QBMPS as applied by Happy Cow which includes food safety parameters gives smallholder farmers an opportunity to earn bonuses on top of the normal milk prices for milk that meets the set standards. Parameters used are: total bacterial count, presence of antibiotics residues, adulteration (freezing point), and total solids (including fat & protein). Happy Cow works with milk Collection and Bulking Enterprises (CBE's; sometimes also referred to as cooperatives) who collect milk from their smallholder members in Nakuru and Nyandarua Counties. Happy Cow developed its own standards, which were less stringent than the KEBS industry standards, but considered more realistic and attainable by smallholder farmers and CBEs, as shown in **Table 1.**

Table 1: QBMPS and KEBS Standards‡

Test	Grade	QBMPS Standard‡	KEBS Standards	Premium /penalty Score[æ]
Total plate count (Units in cfu/ml)	A	0 - 2,000,000	<200,000	50
	B	2,000,001 - 10,000,000	200,000 - 1,000,000	0
	C	>10,000,001	>2,000,000	-50
Antibiotic residues	All	Negative	Negative	15*
Freezing point	All	-0.500	-0.525 to -0.565	20[#]
Total solids	All	>11%	>11.75%	15[#]

([æ]Premium or penalty score given to milk of the corresponding to the QBMPS standard (column 3); *positive milk is discarded; [#]otherwise a 0 score; ‡Source: Happy Cow).

In the QBMPS, milk samples are collected and analysed daily for all the above mentioned parameters. In order to reduce the costs for testing, about 5 – 10 farmers are grouped such that their supplied volumes add up to fill a can of 50 kg. These farmers are maintained in the same groups to assure continuity and consistency in the payment system. Sampling is done randomly to ensure that each can is tested twice a month for the above mentioned parameters. The payment module is based on a summation of the scores obtained from the last column of Table 1. as shown (**Table 2**).

Table 2: Payment modules employed

Grade	*Total score	Payment	Amount (KES)
A	70-100	Premium	+2
B	40-69	Standard	+1
C	<40	Penalty	0

*Calculated by summing the scores from Table 1

The focus on public and private good aspects to understand the pilot or proof of concept is an innovative approach that will offer unique lessons to those that wish to replicate it.

1.2 Objectives of the study

The main objective of the study is to quantify the public and private costs and benefits of the implementation of the QBMPS piloted by the processor Happy Cow Ltd.

Specifically, the research aims at:

1. Calculating the costs and associated benefits of improving the quality of milk for the farmers, cooperatives and processors.
2. Assessing the public health benefits related to reduced incidence of milk related illnesses as a result of improved milk quality.
3. Providing recommendations on considerations needed in order to upscale the QBMPS.

1.3 Piloting the QBMPS

Happy Cow Limited was founded in 1994, a dairy manufacturer based in Nakuru, Kenya. Happy Cow is supplied by 2,000 small scale dairy farmers, each producing an average of about 8 kg of milk daily and collected through CBEs (Collection and Bulking Enterprises also known as cooperatives in other studies); New **Ngorika** Milk Producers Limited in Nyandarua County and **Olenguruone** Dairy Farmers Cooperative Society in Nakuru County respectively.

In November 2014, Happy Cow started the Milk Quality Tracking & Tracing (MQT&T) and Quality Based Milk Payment (QBMP) pilot project together with Ngorika and Olenguruone. This was facilitated by SNV's Kenya Market-led Dairy Programme and funded by the Embassy of Kingdom of the Netherlands in Nairobi.

Happy Cow is advocating and raising awareness of farmers and other chain actors about the benefits of quality milk. The farmers are further motivated through a bonus payment scheme, to invest in various ways (see next section) to assure quality. This study seeks to quantify the – public and private - costs and benefits of the major players of this QBMPS; farmers, cooperatives and processors as well as the consumers, so as to determine its prospects of being scaled up in Kenya.

The project's objective is to improve the quality of raw milk sourced from these two CBEs. In Phase 1, Happy Cow introduced the parameters mentioned in Table 1, while in Phase 2 (starting from 1st January 2017), Happy Cow started testing on somatic cells and aflatoxins. So far, these 2 extra parameters have not been included in the bonus system.

2. Overview of costs and benefits of the QBMPS

The costs and benefits of the QBMPS were calculated using data collected from secondary sources, combined with interviews and additional information collected from farmers, CBEs, processors, consumers, health workers and researchers. These were analysed using various methods that were extensively discussed by experienced researchers. The methods are further described in Annexes 1 – 4.

2.1 Private costs and benefits

The private costs & benefits include the costs and benefits for farmers, CBEs and the processors as business entities.

2.1.1 Costs and benefits for farmers

In analysing the costs and benefits, it was assumed that different farmers would make dissimilar levels of investments into the QBMPS, which would also reflect in their benefits. Four milk quality levels were considered with three targeting Grade A, B and C milk (described in Tables 1 and 2), and mixed milk. The additional costs (investments) and benefits to farmers linked to the various quality levels are shown in **Table 3.** Mixed milk is a scenario made to illustrate the situation of hesitating farmers who are about 50% committed and who venture into but are never fully dedicated to implementing the changes required for the QBMPS. The revenue from forgone milk rejection considers the farmers' benefits due to reduced rejection of milk by the processor. It should be noted that all milk rejected by the processor is discarded and never returned to the CBE. This is different from milk which is rejected at the CBE which is returned to the farmer and often sold through other channels. It is estimated that farmers targeting Grade A milk can reduce milk rejection rates to 0.5% compared to a rejection of 5.8% for those in Grade C category. If this is applied to the average daily sales of 10.71 kg, the farmer can make an additional income of 19.87 KES per day from the forgone revenue from rejected milk due to poor milk quality.

Key benefits per milk category

- At the current market price (of 35 KES), an average farmer incurs an additional cost of 1.55 KES per kg of milk in order to continuously meet the standards for a premium payment of +2 KES (grade A milk). The same farmer also gets an additional 1.86 KES as revenue from forgone milk rejection, giving him a profit of 2.31 KES per kg of milk.
- A farmer who continuously meets the standard for Grade B milk incurs an additional cost of 1.25 KES and gets a benefit of 2.09 KES, which comes from 1 KES for quality payment and 1.86 KES made by a forgone

loss of income due to milk rejection. This gives him a net profit of 0.92 KES per kg of milk.

- Because there is no extra payment for farmers with Grade C milk, they make a net loss (difference between additional revenue and additional cost) of -0.20 KES per kg of milk due to inevitable costs they incur in order to be paid following the QBMPS scheme. Therefore, being part of a QBMPS without being committed would lead to a net loss.
- Most farmers are not consistent with their investments to the QBMPS and have a fluctuating milk quality that ranges from grade A to grade C, represented by a "Mixed" quality in **Table 3**. They tend to limit their investments in the QBMPS and as such they do not always get the premium price. This negligence of farmers is prompted by the existence of many alternative markets for the farmers where milk quality is not tested. Such farmers have a net profit of 0.27 KES per kg of milk, which is less attractive than the profits made by farmers constantly supplying Grade A and Grade B milk. Because this amount is small, it might not be noticed by such farmers and could lead to dissatisfaction with the system.

The higher the investments by farmers, showing their level of commitment, the higher their profits. In order to attract more benefits from the QBMPS, it is advisable for farmers to be more committed by being optimal and consistent in their investments.

Table 3: Variation in costs and benefits for farmers involved in the QBMPS

	Unit	Additional costs and revenue per kg for different milk grades (based on interviews with 90 farmers)				Per farm per day
		Grade A	Grade B	Grade C	Mixed	Grade A
Milk quantity considered	kg	1	1	1	1	10.71
QBMPS payment	KES	2	1	0	0.5	21.42
Revenue from forgone milk rejection	KES	1.86	1.09	0	0.6	19.87
ADDITIONAL REVENUE	KES	3.86	2.09	0	1.1	41.29
Feed costs*	KES	0.15	0.15	0	0.07	1.56
Milk equipment costs	KES	0.08	0.08	0.08	0.08	0.85
Water costs	KES	0.17	0.08	0.08	0.08	1.8
Housing costs	KES	0.53	0.53	0	0.35	5.71
Additional time for cleaning and attending trainings	KES	0.62	0.33	0.04	0.25	6.64
ADDITIONAL COST	KES	1.55	1.17	0.20	0.83	16.56
Additional profit/loss	KES	**2.31**	**0.92**	**-0.20**	**0.27**	**24.73**

*Costs for including a mycotoxin binder in the feed

Additional benefits

- **Social/business inclusion**: Another benefit of this form of the QBMPS - designed for smallholders - is the ability to enhance their inclusion into higher value (more profitable) dairy supply chains. Due to their small quantities and their quality issues, they are likely to be excluded from a formal dairy chain. The QBMPS gives the smallholder farmers a chance to improve their production and sell their milk at a competitive price through a reliable market channel, as opposed to the informal market where prices are highly volatile and milk collection is irregular and might be absent during peak production periods leading to possible loss of revenue for the farmer.
- **Chain integration:** The QBMPS encourages grouping of farmers and the organisation of the system strengthens both horizontal and vertical integration along the dairy chain, making it more robust. This also gives them an advantage of becoming more trustful business partners attractive to other actors such as input suppliers, financial institutions etc.

Milk transportation by motor bike

- **Productivity gains:** Farmers practicing the QBMPS receive a lot of training, including animal husbandry and feeding. These good practices will contribute to improved milk quality, and might as well lead to higher production volumes.

2.1.2 Costs and benefits for CBEs & processor

Costs for CBEs and processor

Figure 1 shows the costs per kg of milk for various investments made by the processor and the CBEs in the QBMPS (without considering subsidies). The annual depreciation was used as a cost for fixed investments. All total annual costs were divided by an average daily milk intake of 9,000 kg milk (based on 2016 intake levels) to get the cost per kg. The processor spends an average of 3.05 KES per kg and the CBE about 0.56 KES per kg of milk that goes through the QBMPS.

Looking at the processor's costs, about 40% of the total costs were used for consumables in the laboratory, while 20% were used for hardware and about 15% each for training of farmers and benefits for project staff. Interestingly, only 8% of the total costs was used in bonus payments to farmers. For the CBEs, 90% of costs were on staffing, while the other 10% was almost equally distributed between laboratory consumables and software development. These figures show that in terms of costs, in the Kenyan context involving smallholders, building a QBMPS is a lot more about equipping laboratories, paying for lab consumables, training farmers and paying staff, rather than about paying bonuses to farmers.

Benefits to the CBEs

An average of 41 KES is paid to the CBEs by the processor per kg of (bulk) milk collected. It should be noted that the bulk milk will be a mixture of Grades A–C and that the CBE charges a fixed amount of 6 KES/kg of milk to the farmer's milk price, which is independent of the milk quality.

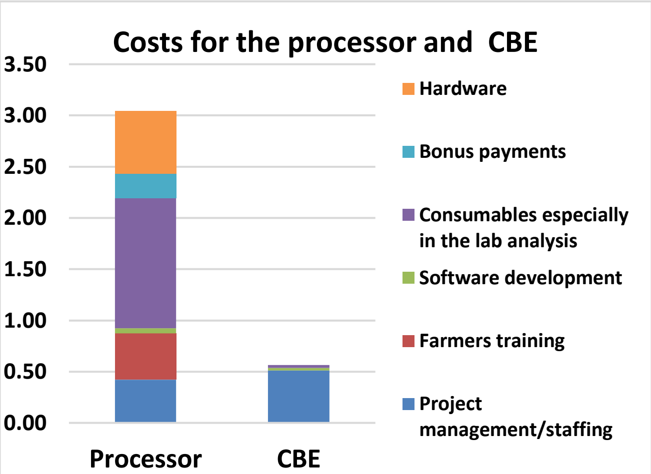

Figure 1: Costs for processors and CBEs

Based on discussions with the CBEs, it was evident that the QBMPS brought about huge reductions in the proportion of milk that was rejected by the processor. Milk rejected by the processor is not paid for, leading to a loss of 35 KES to the farmer and 6 KES to the CBE per kg of rejected milk. Meanwhile, milk that is rejected at the CBE is returned to the farmer. The milk rejection levels for different grades of milk were estimated using information from the CBEs. **Table 4** shows the losses which the CBE would make, assuming that all the daily milk collected were of a target grade (for example Grade A), in comparison to a situation where all the daily milk were Grade C. If the CBE's farmers only provide Grade A milk instead of Grade C milk, the CBE would make an extra benefit of 0.32 KES per kg of milk. In the same way, the CBE will make a benefit of 0.19 KES/kg if all farmers deliver Grade B milk and 0.10 KES/kg for Mixed milk.

As is the case with farmers, the increased milk production from productivity gains will also be translated into higher milk intake by the CBE leading to a higher total daily margin to the CBE.

Table 4: Costs and Benefits to the CBE and processor due to reduced milk rejection

	Grade A	Grade B	Grade C	Mixed
CBE				
Total CBE cost per kg of milk (KES)	0.56	0.56	0.56	0.56
CBE benefit per kg of milk as forgone milk rejection (compared to Grade C milk) (KES)	0.32	0.19	0.00	0.10
Profit/loss of CBE	**-0.24**	**-0.37**	**-0.56**	**-0.46**
Processor				
Total processor cost per kg of milk (KES?)	3.05	3.05	3.05	3.05
Processor benefit per kg of milk as forgone mis-production and milk returns* (KES)	0.93	0.74	0.00	0.52
Profit/loss of processor	**-2.12**	**-2.31**	**-3.05**	**-2.53**

**Calculated as additional revenue from sales of finished products which the processor will get due to forgone product returns and mis-production when using the target Grade of milk compared to Grade C milk.*

When poor quality milk is processed, the chances of losing batches of the product are higher than when good quality milk is used. For example, the fermentation of yogurt and cheese may be hindered by the presence of antibiotics in milk. Also, products from milk of poor quality might get spoilt before their envisaged shelf life and will be returned to the processor. The QBMPS has the potential to reduce such occurrences, thus giving the processor an average benefit of 0.93 KES per kg of received milk (**Table 4**).

2.2 Public health costs and benefits

2.2.1 DALYs

To determine the burden of various milk-borne diseases on public health, Disability Adjusted Life Years (DALYs) were calculated. This was calculated from the incidence of the disease and the average productive time lost due to the disease as shown in Annex 3.

Table 5 indicates the incidences of milk related infectious diseases per year. These incidences are based on the current population of 48.46 million and on an estimation of the cases of infectious diseases that are caused by poor milk quality (Kenya Dairy Board, 2017; World Bank, 2017).

Table 5: Incidences and DALYs of infectious diseases derived from milk consumption in Kenya

	*Incidence (cases/year)	#DALY (years)
Tuberculosis	3,392	16,045
Brucellosis	28,107	19,259
Listeriosis	8,238	3,521
Salmonellosis	26,653	563
E.coli infections	23,745	2,089
Campylobacter infections	2,423	10,694
Coxiella burnetti	1,890	922
Total		**53,093**

*Source: KDB, #Source: Own calculation. NB: These incidences are based on an estimation of incidences of infectious diseases caused by poor milk safety. However, since proper microbiological research on the cause of infectious diseases is often lacking, it cannot be said with certainty that all these incidences are indeed caused by poor milk quality.

The table shows that the impact of brucellosis is especially substantial. This is mainly because brucellosis is transmitted to a large part of the population at the same time and because the duration of the illness is relatively long. The DALY for brucellosis is 19,259, which means that each year in the total population 19,259 healthy life years are lost due to brucellosis. On the contrary, although salmonellosis occurs more frequently, because of the low mortality rate and the short duration of the illness, only 563 healthy life years are lost each year. Campylobacter has a high DALY primarily because young children are vulnerable to this illness and the mortality rate is high. Tuberculosis also occurs frequently and has a relatively high DALY, particularly due to the higher severity for HIV positive patients.

In total, as estimated 53,093 healthy life years are lost annually in Kenya due to milk related infectious diseases. Considering an average lifespan of 62.13 (World bank 2017) this gives us an average loss of 855 full lives per year due to milk related infectious diseases. It should be noted that due to the lack of reliable information on the losses due to use of antibiotics, mycotoxins and harmful preservatives like hydrogen peroxide, they have not been considered in the above calculations.

2.2.2 Direct and indirect health costs

The direct costs of being ill 'represent the value of goods, services and other resources consumed in providing care due to an illness' while the indirect costs result from output lost because of reduced productivity due to illness (McLinden et al., 2014 p. 2). More details on the calculation of these costs are shown in Annex 3. **Table 6** also shows the indirect costs and the total (direct and indirect) costs per year due to milk related health hazards. These total costs are estimated at 437 billion KES. However, actual costs may differ, because of the missing costs due to hydrogen peroxide adulteration.

The cost variation is mainly due to the different medicines needed to treat the illness and different durations of treatment. Treatment of brucellosis and listeria is especially expensive, as they require the use of expensive antibiotics for a prolonged time period.

Milk reception at the CBE

Milk collection and transportation

Table 6: Estimated total annual costs of milk related health hazards in Kenya (1,000,000 KES)

Illness	*Cost per case	Total direct costs	Total indirect costs	Total costs
Tuberculosis	0.02	76.36	2,381.85	2,458.21
Brucellosis	1.21	33,945.69	2,858.92	36,804.61
Listeriosis	43.02	354,384.74	522.67	354,907.40
Salmonellosis	0.44	11,609.13	83.59	11,692.72
E.coli infections	1.00	23,767.21	310.17	24,077.38
Campylo-bacter	0.16	397.69	1,587.54	1,985.23
Coxiella burnetti	0.001	1.95	136.86	138.82
Antibiotics	-	4,346.51	-	4,346.51
Aflatoxins	-	8.73	2.49	11.22
Total		**428,538.00**	**7,884.09**	**436,422.09**

Exchange rate: 1 USD = 102 KES
*Source: KDB, 2017

Costs due to antibiotic resistance

As discussed before, antibiotics residues in milk may cause antibiotics resistance. In case bacteria become resistant, treatment becomes more difficult. Antibiotics are often used to treat diseases common in developing countries such as tuberculosis, malaria, HIV/AIDS, food poisoning, pneumonia, sexually transmitted diseases, etc. In case the standard antibiotics do not work anymore in treating these illnesses, doctors have to prescribe 'last-resort' medicines, which have more adverse side effects, are far more costly and are often not easily available in low income countries. Sometimes the bacteria could become resistant to the 'last-resort' medicines, leaving the patient with no other treatment possibility. Although it is hard to estimate the costs related to antibiotic resistance, it is certain that it causes economic losses, due to higher rates of illness, increased duration, decreased productivity and higher costs of treatment (Cosgrove & Carmeli, 2003; Levy & Marshall, 2004; Okeke et al., 2005; World Bank, 2016; World Health Organization, 2015). The Kenya Dairy Board made an attempt to quantify the costs caused by antibiotics resistance linked to milk and estimated the costs at 4.3 billion KES each year (Kenya Dairy Board, 2017).

Costs due to aflatoxins

The costs of aflatoxins are equally difficult to estimate, as their effects are not yet fully understood. Research done mainly focuses on the market-related costs of aflatoxin exposure, such as lost harvest. Aflatoxin can have four major effects on human health: acute poisoning, stunting, immunosuppression and increased risk of liver cancer. Because Kenyans consume more milk than the average African population, they have a higher risk to consume aflatoxin-contaminated milk (Karaimu, 2014). Although causality is not yet confirmed, it is widely assumed that aflatoxin exposure has an effect on stunting in children, which can cause adverse health outcomes beyond childhood (Wu, 2013). The link between aflatoxin and immunosuppression is shown in several studies, however the exact impact of immunosuppression on health is not yet studied (Wu, 2013). More is known about the relation between aflatoxin and liver cancer. Wu (2015) estimated that 23% of all liver cancer cases can be attributed to aflatoxins. Considering a maximum carry over rate from aflatoxin B1 to Aflatoxin M1 of 3.2% (Van Eikeren et al 2006), and applying this to Kenyan milk gives the results shown in **Table 6**.

Although liver cancer is the third-leading cause of cancer deaths worldwide and mortality follows in most cases within three months, the DALY is not that high because people are most vulnerable around the age of 60 (Wu, 2013). This means that relatively few healthy years of life are lost. Treatment of liver cancer is expensive, indicated by the total direct costs. However, treatment costs heavily depend on the case and stage of the cancer.

2.2.3 Health cost reduction scenarios

The QBMPS was introduced to improve the quality of milk and in this way to i) reduce health risks and costs and ii) enhance business benefits for various dairy supply chain actors. However, at the point of this study the system was not yet working optimally and the quality was not yet substantially improved. Once the system works optimally and the quality of the milk improves further, this should result in a reduction in the incidence of milk related health hazards and could lead to a reduction in related health costs. Previous studies estimated that disease incidences would reduce by 50% annually when interventions are introduced (Government of New Zealand, 2010; Kenya Dairy Board, 2017). This rate of reduction seems however unlikely with the current status of the QBMPS. The implementation of the system is still being improved to meet its optimal potential, and we estimate that the current efforts have generated milk of "Mixed" average quality level as described in **Table 3**. Therefore, in **Table 7**, different rates of reduction for incidences are applied. The reduction rates of 10%, 20% and 50% are used to reflect improving effectiveness of application of the QBMPS.

KDB estimates that if all Kenyan milk went through a well-functioning QBMPS, then an annual reduction of 50% in diseases incidences would be attained. Meanwhile, with mixed milk, likely only a 10% reduction of incidences of milk related illnesses will be attained.

Table 7 shows the costs for these different scenarios. It appears that costs per year will decrease rapidly in case a reduction in incidence cases is accomplished, to a reduction of 220 trillion KES per year in case of 50% reduction of incidences. When calculated per kg of milk, this scenario will result in 44 KES in avoided costs per kg of milk.

Table 7: Cost reduction scenarios (1,000,000 KES)

Costs	Current	10% reduction	20% reduction	50% reduction
Total direct	428,538	381,774.76	302,323.95	149,629.74
Total indirect	7,884	7,023.75	5,562.05	2,752.83
Total costs	436,422	388,799	307,886	152,383
Total avoided costs	-	**47,624**	**128,536**	**284,040**
Avoided cost per kg milk		**9.52**	**18.17**	**44.10**

However, a scenario of "Mixed milk' is more likely, in which the average milk quality is somewhere between Grades B and C. In this scenario the farmer's profit reduces to 0.27 KES and the CBE and Processor make a loss totalling 3.2 KES. The public health benefits from the QBMPS in this scenario of 'Mixed milk' will still amount to about 10 KES per kg milk, which is considerably higher than the cost of the QBMPS. This justifies an initial allocation of public/donor funds into development of QBMPSs, but these costs would be reduced overtime once the initial fixed investments are made. If funds of 3.2 KES per kg milk would be allocated to the QBMPS, they would cover the net losses to the CBE and processor and would stimulate set up of the QBMPS.

3 Conclusions and recommendations

Table 8 summarises the costs and benefits of various actors. It shows that among the milk chain actors, the farmer is the greatest beneficiary from a well-functioning QBMPS. A farmer producing Grade A milk will have an extra profit of 2.3 KES per kg of milk, being the difference between his additional costs and benefits per kg of milk. Meanwhile, the CBEs and processors have additional costs which if not being incorporated in the price charged to consumers will give them a loss (from 0.24-0.46 and from 2.12 to 2.75 respectively). This is likely to influence their commitment to the QBMPS.

Table 8: Summary of costs and benefits per kg of milk

	Grade A	Grade B	Grade C	Mixed
Farmer				
Costs	1.55	1.17	0.20	0.83
Benefits	3.86	2.09	0	1.1
Profit/loss	2.31	0.92	-0.20	0.27
CBE				
Costs	0.56	0.56	0.56	0.56
Benefits	0.32	0.19	0.00	0.10
Profit/loss	-0.24	-0.37	-0.56	-0.46
Processor				
Costs	3.05	3.05	3.05	3.05
Benefits	0.93	0.54	0.00	0.30
Profit/loss	-2.12	-2.51	-3.05	-2.75
Public				
Costs	Public Investment			
Benefits	44.10	18.17	0	9.52
Profit/loss	44.10	18.17	0.00	9.52

3.1 Progress Happy Cow Project to date

During the past 3 years a number of investments were made in this Project. These covered milk testing equipment and laboratories, milk cans and can washing facilities, the cold chain, collection points in the routes, motorbike racks, software for data storage, processing and bonus payments and KENAS accreditation of the Happy Cow laboratory. These and other investments have improved the efficiency of milk collection and due to better testing, the average quality of milk delivered at Happy Cow's factory improved (especially reduced occurrence of antibiotic residues). Although the project made progress, the change has been slow and only a few farmers qualified for bonus payment. Major challenges proved to be:

External factors:

- Lack of enforcement by relevant authorities on hygienic milk handling practices and quality standards.
- Lack of common strategy towards milk quality amongst the processors; a market that is driven by volumes instead of quality
- No level playing field of processors and CBEs vis-à-vis hawkers who buy milk directly from farmers; frequent side selling and low level of farmer's loyalty to CBEs.
- Prolonged drought experienced in year 2017 resulting in significant financial setbacks.

Internal factors

- Low awareness, skill level and weak governance of the dairy value chain actors to obtain quality milk.
- Basic infrastructure (e.g. potable water, cold chain, food grade milk cans, etc.) and milk quality polices at CBEs are inadequate in place. This results in unhygienic milk handling, too long milk cooling duration, unethical behaviour of some individuals (e.g. adulteration) and finally high bacteria load.

3.2 Considerations for upscaling

For upscaling of the QBMPS, some aspects need to be considered. Some initial investments were made to meet the basic infrastructure that is required for any good milk collection system to function according to the Kenyan regulations, irrespective of whether there is a QBMPS implemented or not. Based on the current case, we calculated an additional cost of **1.73 KES** per kg of milk for putting basic systems in place. This includes simple laboratories, clean water and can cleaning facilities, cooling tanks and using aluminium cans in all milk collection centres. It is expected that these extra costs will be required, in addition to the costs shown in Figure 2, during the pilot phase and during scaling up of the QBMPS.

As compared to the pilot phase, the processor's and CBEs' costs during the upscaling phase are expected to reduce. Both hardware and software costs would reduce, as they will mainly require maintenance. The cost for laboratory consumables is expected to decrease during upscaling as well. It is assumed that when scaling up, sampling will be done from larger units, like 150 kg collected by a motor bike transporter or 500 kg collected per route by a tractor/lorry, instead of 50 kg cans of milk currently sampled. Such scaling up of the sampling unit will substantially reduce the sampling and labour costs.

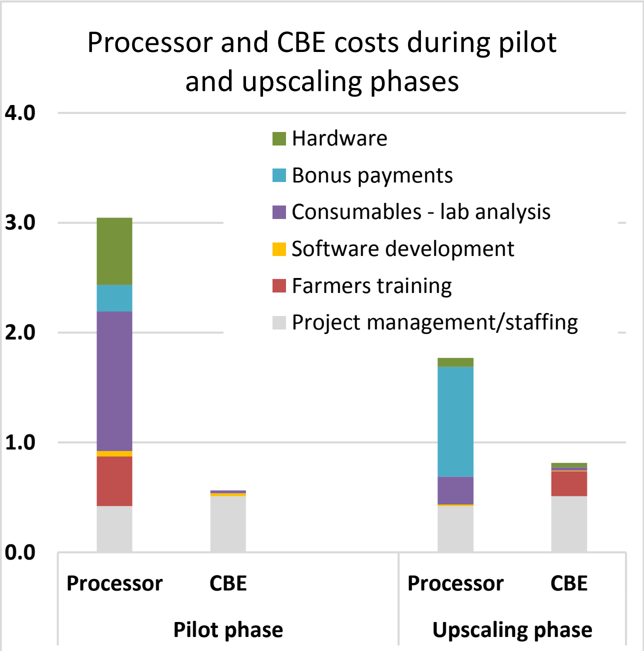

Figure 2: Costs of the processor and CBE during pilot and scaling up phases

Most importantly bonus payments will increase during the upscaling phase, because more farmers would comply to better milk standards, justifying a bonus payment. Sustainable development of the dairy sector in Kenya is important in order to meet the growing consumer demand. It is projected that Kenya's per capita consumption of milk will reach 220 kg/day by 2030. The dominance of an informal sector coupled with weak enforcement of quality regulations has raised concerns about milk quality in the country. The current payment structure of milk emphasizes quantity rather than quality in both the formal and informal sector. In this structure, actors do not have the incentive to improve on milk quality - they get the same payment, regardless of the investments made to improve milk quality.

A functional QBMPS gives incentives to all players along the dairy chain to improve the quality of milk. Based on the pilot program implemented by Happy Cow, farmers delivering Grade A milk would receive an additional KES 3.86 for every kg of milk delivered to the CBE. This would require that the farmer practices hygienic milking, observes withdrawal periods for antibiotics, separates morning and evening milk and attend regular trainings. The costs incurred by the farmer amount to 1.55 KES/kg, resulting in an extra profit of 2.31 KES/kg. The CBEs would incur a cost of 0.56 KES per kg of milk and have a benefit of 0.32 KES/kg, leaving them with a net loss of -0.24 KES/kg. For the processor, the system requires equipping a laboratory, employing quality control personnel, acquiring a good software, etc., at the cost of 3.05 KES/kg and accruing benefits of 0.93 KES/kg leading to a loss of -2.12 KES per kg of milk. Next to the private benefits to the value chain actors (farmers, CBEs and processor), these actions would result in public health benefits amounting to 44.1 KES/kg for grade A milk, 18.17 KES/kg for Grade B milk and 9.52 KES/kg for mixed milk. These are quite huge benefits, which could justify public investments into the QBMPS.

Based on the information collected, the QBMPS is a step in the right direction towards improvement of milk quality in Kenya. The processor as well as the CBEs incurred huge costs in setting up the system and both made cash losses (subsidies not considered). From the cost-benefit analysis it is evident that the QBMPS is not yet viable to auto-finance itself in the current Kenyan situation. Since this was a pilot phase, some funding was received from the Embassy of the Kingdom of the Netherlands in Kenya to cover part of the processor and CBE costs, which compensated for the losses.

3.3 Recommendations

In order to fully integrate and replicate the system, the study put forth the following recommendations for improvements in the implementation of a QBMPS:

Farm level: Recommendations at farm level include full implementation of proper hygiene, adoption of aluminium cans, separation of morning and evening milk and timely delivery of milk to the milk collection points. Farmers producing milk of grade B and C can be nudged to produce grade A milk as they will need to make slightly more investments to get much more profits.

Cooperative (CBE): The CBEs should be stringent in checking the quality of milk delivered, either at the milk collection point or at the CBE for farmers who deliver to the CBE directly. This means that all employees involved in handling and transporting the milk must be trained on hygiene practices. This calls for development and enforcement of strict standard operating procedures. As much as its main objective is finding a market for its members' produce, the CBE must be willing to reject poor quality milk to ensure quality of milk supplied. Transporters should be employed by CBEs to assure an optimal quality of milk. Outsourcing of milk collection and transportation compromises milk quality.

CBEs should invest in fast cooling tanks and in potable water and can washing station. They should only use aluminium cans for milk collection and transportation

Processors: Just like the CBE, processors must not accept poor quality milk. It should strictly and continuously monitor the milk collection process of the CBEs and put a robust milk quality tracking and tracing system in place. Similar to the CBEs, processors also incur losses at this stage and we recommend that they also get support during the first years of implementation of the QBMPS until it can refinance itself.

Government/regulatory: The regulatory authority should ban the use of plastic cans completely. It must phase out the raw milk market, and it should have entry barriers for CBEs to enter the business of milk collection and marketing, amongst others these CBEs must have proper water supply, cleaning and cooling infrastructure and a lab with lab equipment. CBEs should have an employed food technologist or a QA staff. CBEs must have policies and SOPs in place for clean milk handling.

It should streamline the dairy sector towards a formal sector, since a QBMPS can only be implemented in such conditions. It should also invest in quality control staff who will enforce quality regulations in all the counties. Part of the investments currently done by the processors and CBEs could be made by the government. An example is training of farmers, which cost the processor 0.45 KES per kg of milk during the pilot phase. Also due to the huge public health benefit, it is advisable for the government to allocate funds to support the dairy sector in building up sustainable QBMPS that include food safety parameters.

Consumer organisations/consumers: Consumers should be duly informed on the difference in quality of milk which goes through a QBMPS, they might accept a higher price for products generated from it, which could (partly or entirely) compensate the costs made by the processor.

Finally, the QBMPS has a huge potential to improve public health by cutting down on the enormous health losses of 53,073 life years lost annually nationwide due to milk-related diseases, with public health costs amounting to a total (direct and indirect) cost of 4,4 billon KES/year.

This study thus indicates that implementing a QBMPS gives an undoubtable potential to address milk quality issues leading to reduced health risks of consumers and at the same time improve farmers revenues and multiple benefits for various dairy chain actors in Kenya.

Limitations to this study

This study has a few limitations worth mentioning.

- The calculations of benefits from the processor only consider yogurt and cheese as final products as in Happy Cow ltd. Considering other products might alter the results.
- Some costs might be required for regulation of feeds in order to reduce aflatoxin to tolerable levels. These have not been considered.
- Improving milk quality might not necessarily translate into improved health impacts as assumed in this study because other factors like milk pasteurisation, human resistance, etc. also play a role. Similarly the impact of antimicrobial residues and aflatoxin in milk on human health is controversial in literature.
- The benefits do not consider trade benefits which might arise from marketing of a better quality milk.
- Environmental benefits arising from less loss (waste) of milk, more productive cows and a more efficient dairy have not been quantified.

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Weighing of milk at collection point

Annex 1: Milk hygiene and handling practices at the farm level

		Frequency (N= 75)	%
1.	Clean the shed and dispose the dung away from the shed	6	8
2.	Wash the milking vessels with clean water and dry them	74	98.7
3.	Wash hands with soap and dry the hands with towel	72	96
4.	Wash the udder with clean warm water before milking	75	100
5.	Fore-strip each quarter and observe signs of mastitis	16	21.3
6.	Wipe and dry the udder after washing using clean dry towel	47	62.7
7.	Apply milking jelly/lubricant after milking	60	80
8.	Disinfect the teats with teat dip	4	5.3

The table shows the hygiene status of farmers from the two cooperatives that are paid using the QBMPS. It shows that 80% of the farmers applied milking jelly after milking. After milking, teats should be dipped in antiseptic solution to minimize risk of infection but only 5.3% disinfected the teats with teat dip.

Only 41.3% of the interviewed farmers had attended a dairy training in the past one year. Out of those who had attended training, 25.3% had gained knowledge about proper milking and clean milk handling, while the others were on dairy health, pasture establishment and feeding. Although the training offered by Happy cow and the CBEs are free of charge and voluntary, very few farmers had attended the trainings. Farmers who adopt these hygienic practices are more likely to produce grade A and to receive bonuses.

Annex 2: Approach for calculating private costs and benefits

To calculate the private costs and benefits, we followed a value chain approach (VCA). The chain actors considered in this study had been identified in a previous study as farmers, transporters, CBE and processors (Ndungu, 2016). The study was undertaken in Nakuru and Nyandarua Counties, based on the location of the different stakeholders who form part of the dairy value chain.

Sampling was purposively done to permit an in-depth analysis of the costs and benefits. Data was collected through interviews with the stakeholders shown in **Table 1** and through two focus group discussions with farmer groups to understand their perception on the QBMPS.

Table 1: Number of chain actors interviewed

Respondents	Size
Farmers/producers	90
Cooperatives	6
Milk transporters	12
Focus Group discussion	2
Processors	2

factor. In this formula I is the number of incidences, L is the average duration of the case until remission or death in years and DW is the disability weight, which reflects the severity of the disease on a scale from 0 (perfect health) to 1 (worst possible health state). The disability weight

The study applied both descriptive and econometric tools to analyze the empirical data collected. Descriptive statistics have been used to describe the characteristics of the respondents and their cost and benefits in the QBMPS as described in **Annex 4**.

Annex 3 Approach for calculating public health costs and benefits

Three indicators were used to calculate the public health benefits of the quality based milk payment system: DALY, direct costs and indirect costs.

i) DALY

DALYs (Disability Adjusted Life Years) were used to determine the burden of milk related diseases. When a person is born, s/he has a potential number of life years to live in optimal health situation. However, people may lose some of these years of optimal health due to illnesses or death before reaching their life expectancy level. These losses are measured by DALYs. DALYs indicate the burden of disease across the population and indicate the gap between current health status and the ideal situation where people reach their life expectancy levels free from diseases or disabilities (Devleesschauwer et al., 2014; Larson, 2013; WHO, 2017).

DALYs were calculated using the following formulas:

$$DALY = YLL + YLD \quad (1)$$

$$YLL = N * L \quad (2)$$

$$YLD = I * DW * L \quad (3)$$

Where, YLL (Equation 2) corresponds to the number of deaths (N) multiplied by L, which is the difference between the life expectancy and the average age at which death occurs due to a particular milk related illness. The YLL indicates thus the number of years lost because of death. Calculation of the YLL was based on the incidences and number of deaths due to milk related illnesses (adopted from the Kenya Dairy Board (KDB) data), the average life expectancy (based on the World Bank (Wold Bank, 2017), and the average age at which death occurs (based on secondary data and expert interviews). YLD (Equation 3) is the number of milk related incidences in a particular period multiplied by the duration and a weigh indicates the proportional reduction in good health due to an adverse health state (Devleesschauwer et al., 2014). In this study it was adopted from previous researches (Salomon et al., 2012, 2015). For tuberculosis only, a differentiation was done between HIV infected patients and non HIV infected patients, as the severity for these two types of patients differs and thus the disability weights.

ii) Direct costs

Direct costs of being ill 'represent the value of goods, services and other resources consumed in providing care due to an illness' (McLinden et al., 2014 p. 2). These costs include the basic medical care expenditures, such as the expenditures for diagnosis, treatment, continuing care, rehabilitation, terminal care and transportation costs (Hodgson & Meiners, 1982; McLinden et al., 2014). To estimate the direct costs of milk related illnesses, the incidence-based costs approach was used; it is often used for analyses that 'seek to measure the savings, or benefits, of preventing a new case of disease' (Hodgson & Meiners, 1982 p. 431).
The direct costs were calculated as follows:

*Total direct costs = incidences of specific illnesses * direct costs per incidence* (4)

iii) Indirect costs

Besides direct costs, also economic indirect costs exist. These costs result from output lost because of reduced productivity due to illness. Indirect costs account for losses in productivity due to an illness or death (McLinden et al., 2014). These indirect costs were measured using the human capital approach, which is commonly used to measure indirect costs of illness (Hodgson & Meiners, 1982). These losses were calculated by multiplying the life years lost (DALY) and the average productivity per year, as shown in Equation 5.
Total indirect costs = DALY for milk related illnesses * average productivity /year/capita (5)

The total costs were calculated by summing direct and indirect costs for all milk related illnesses.

Public investments

The set-up of the QBMPS at Happy Cow was supported by the Embassy of the Netherlands in Kenya, in order to pilot sourcing quality milk from smallholder dairy farmers, who make up majority (80%) of the producers in Kenya. This public investment was made in the form of a subsidy. Note that these costs have not been deducted in the calculations and the above costs reflect the full cost of the QBMPS.

Focus group discussions with farmers

Annex 4: Overview of costs and benefits from the QBMPS

	Cost incurred in a QBMPS	Benefits from a QBMPS
Producer	• Milk handling, storage and transportation • Infrastructure – housing, etc. • Sourcing quality & more expensive feed • Use of suitable milk containers for storage and transport • Disease prevention and proper treatment • Time for training and extension • Additional time for proper milk handling and hygiene	• Increased revenues from better quality milk • Greater incentive to invest in infrastructure • Move from the informal to the formal sector • Increased milk yield from improved feed quality • Faster milk collection • Less milk rejection • Safer milk for household consumption • Lower animal health costs
Cooperative	• Training, extension and supervision • Recruitment of new staff • Cost of software for the tracking and tracing system • Higher transportation costs • Investment in bulking and cooling facilities • Investment in suitable collection centers and milk quality monitoring	• Milk testing facilities • Increased milk volumes • Better management practices by the farmers • Better quality milk from the farmers • Higher revenue from milk • Faster milk collection due to shortening of collection duration • Less milk rejection
Processor	• Training and extension • Training and supervision • Investment in adequate milk testing facilities and products • Marketing costs • Investment in the quality tracking and tracing system • Recruitment of new staff • Investment in better storage and cold chain management	• Higher quality of the processed products and premium prices • Longer shelf life of products • Increased product volumes due to higher milk solid content • Less mis-production/ rejected batches • Lower processing costs of shorter processing time • Shorter pasteurization time • Increased access to export markets and higher prices • Improved organoleptic quality such as flavour, odour and appearance of products
Consumer	• Price of milk purchase	• Improved shelf life of the product • Safe milk • Higher quality and higher nutrition rate • Lower medical bills • Longer shelf life products • Higher product safety • Possibility to export or sell in niche markets • Possibility to increase margins

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