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Options and challenges for organic milk production in East African smallholder farms under certified organic crop production

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ABSTRACT

Many East African smallholder farms with certified organic crop production, also rear animals. Although farming systems are mixed, there is often very little integration and synergy between the different enterprises. The aim of this article is to suggest and discuss different development scenarios for organic dairy production, based on data from three East African studies of dairy production at certified organic cash crop farms. The following questions are explored for two categories of 'model farms' in Kenya and Uganda, respectively: 1) Can smallholder farmers benefit from keeping organic dairy cattle, and under which conditions can it be viable, given the current challenges? 2) How can the dairy production be integrated into the farm and create synergy with the different farm elements? 3) What would need to change if their milk was to become certified organic and farmers had to comply with organic principles and standards for dairy farming? Based on data and estimates from on-farm case studies at Kenyan and Ugandan smallholder dairy farms, in combination with literature, potential development scenarios are outlined. The study concludes that there are good possibilities for more local recirculation of feed and manure, although with limited benefits when there are only few animals with short lactations on the farm. Involvement of local communities in feed production and use of grazing areas seems to be a good option to the mutual benefit of both. If certified organic smallholder farms should diversify their income through sale of organic milk, they would need a secure market. Depending on the cost of certification, these farms will only benefit from sale of organic milk if they can produce milk year round at a scale, which allow them to benefit from the effort to give animals organic feed, an effort including establishment of grazing and local feed production that comply with organic standards. Outdoor stay and grazing continue to challenge many smallholder milk producers especially with Holstein Friesian types of cows, and more robust breeds are needed. In addition, many smallholders do not have sufficient land to permit grazing around their homesteads, where the animals live.

Organic standards regarding animals need improvement and precision, especially requirements for grazing areas and feed. Certification comprising whole farms including the animals, and not only crops for export, will enhance crop-animal integration.

1. Introduction

East Africa has a considerable certified organic production, with Uganda having the highest number of certified organic producers in Africa (Willer and Julia, 2014). The major drivers of this development in East Africa have been international traders and marketers, who have promoted organic agriculture and products aiming at export markets for horticultural products, in particular Europe and USA. Even though approx. 95% of certified global organic production is sold in the USA and Europe, growing markets within Africa are emerging (Anecho et al., 2017; Hauser and Delve, 2007; ICROFS, 2010; Mpabila, 2018; Murimi et al., 2017a, 2017b; Nalubwama et al., 2016a; UN, 2008). The focus has been on certified organic plant production, because it could be exported. The animals have been largely ignored, not only as a

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Table 1

Data describing two selected current dairy farm situations in Kenya and Uganda, estimated from data collected 2012–2014 in Kajaido and Kiambu counties, Kenya (Odhong, 2014), as well as in Luwero and Kayunga districts, Uganda (Nalubwama, 2018).

	Kenyan case (1 Euro = 124 KES)	Uganda case (1 Euro = 4396 Ush)
Location of study sites	Kajaido County (Ngong) and Kiambu County (Dagoretti and Kikuya); 55 farms with certified organic crop / vegetable production and commercial milk production.	Luwero and Kayunga districts; 30 farms with certified organic pineapple production and dairy cows kept under different systems, mainly for own milk consumption.
Overall description of the farming system	Zero-grazing systems with Holstein Friesian type cattle (450 kg live body weight); commercial milk markets.	Zero-grazing (tethering on farm yard), local (mostly short horn zebu) or crossbred cows (350 kg live body weight).
Land total	8.2 acres, of which 0.8 acres is used for compound and cow house,	7.4 acres including homestead and animals 1.2 acres, and land for pineapple production (av. 2.6 acres).
Dairy cattle	Estimated 2 cows in milk at all times + young-stock*)	
Av. milk yield	7 kg/cow/day	5 kg/cow/day
Lactation length	240 days	150 days
Calving interval	420 days	420 days
Age at first calving	33 months	33 months
Mortality rate before 1st calving	20%	
Hired labour	3907 KES/month/farm (32 Euros)	152.760 Ush/month/farm (34 Euros)
Veterinary costs: treatment of acute disease, tick/ parasite vaccinations,	2110 KES /cow/year (17 Euros)	126,000 Ush /cow/year (29 Euros)
Breeding costs**)	Insemination or bull; 10 Euro/cow/year	Taken to good bull; 11 Euro/cow/year
Sold animals	90,871 KES/year/farm***) (733 Euros)	835.621 Ush/year/farm****) (190 Euros)
Estimates reg. organic production	Bonus for milk certified organic: +25% Extra feed cost for organic feed: +15%	

*) The estimates in the Kenyan case is based on data from Odhong (2014) and the estimates in the Ugandan case is based on data from Kiggundu (2015) and Nalubwama (2018). In the Kenyan case, 2 cows in milk at all times was realistic, supported by other studies, e.g. Omondi and Njehia (2014); at the Ugandan farms the average number of cows was sometimes smaller than 2 cows, but we decided to carry through a case where there would always be milk available from the herd under the given circumstances. This means that with a lactation length of 150 days and a calving interval of 420 days (Nalubwama, 2018), there are 6.6 cow units per farm.

**) Makoni et al 2014 report costs of 12 USD per AI for Kenya and Uganda

***) Estimated 0.4 cow, 0.8 heifer calf and 1.2 bull calf (assuming that all calves survive the milk/suckling period of 3 months.

****) Estimated 0.7 cow, 1.3 heifer calf and 1.9 bull calf per year from the herd, assuming that all calves survive the milk / suckling period of 3 months.

fundamental part of organic farming, but also their potential synergies with plant production, as well as the interesting opportunity presented for sale of certified organic animal products primarily to local markets (Kiggundu et al., 2014; Nalubwama et al., 2011; Odhong et al., 2014). Odhong et al. (2014) and Nalubwama et al. (2014a, 2014b) emphasised how the animal herd and plant production seem to 'co-exist', but not as fully integrated farming systems, since the nutrient recycling is not fully developed (Nalubwama et al., 2011, 2014b; Odhong et al., 2014). In this context, 'integration' means making each of the farm components work in synergy with others, so that they altogether form a larger whole, seen from a farming systems approach. Many organic standards are not fully developed for animal production, for example the organic feeding standard documented in the EAOPS is not conclusive even though it has been considerably developed over the years (Kiggundu, 2015; https://www.organic-standards.info/en/documents/East-African-Organic-Product-standard,25). Majority of farmers have small herds, producing milk for the family and selling only small amounts of milk on local market. In Kenya, Wambugu et al. (2011) estimated that the informal milk market controls about 70% of the total amount of milk marketed, and a large part of the milk used is raw and not processed in any way. This informal sector is important and driven by the traditional preferences for fresh raw milk and its relatively lower cost, often offering both higher prices to producers and lower prices to consumers (Wambugu et al., 2011). This could potentially be an opportunity for selling good-quality organic milk, with or without certification.

There is a need to explore whether integration of livestock into organic farming systems can create opportunities for farmers to benefit from synergies between the different enterprises on the farm and innovations. Some topics for exploration would include how by-products from a high-value crop production might be used as high-quality feed for the animals (Kiggundu, 2015), how cows can be integrated with the organic cash crop production to enhance nutrient cycling within the farm and between marginal lands and homesteads (Mubiru et al., 2011), and lastly, how certified organic livestock products can be marketed to give farmers more diversified opportunities for income generation.

There are several questions, which need to be answered regarding smallholder farmers' incentives for keeping organic dairy cattle, and what need to change for the dairy production be integrated into the farm. Modelling nutrient and resource flows of such smallholder farms can give a relevant basis for discussing different options for better integration between animal and crop production on these farms with diversified production.

This article is built on results of on-farm case studies involving smallholder dairy herds in Uganda and Kenya, supplemented with information from literature (e.g. on feed value and yields), and will also highlight issues in the current regulation and practice of organic animal farming of relevance for the further development of an organic dairy sector. The aim of the article is to suggest and discuss different development scenarios for organic dairy production, organised into two categories of 'model farms' in, Kenya and Uganda, based on data in three East African studies of dairy production at certified organic cash crop farms. The following questions will be explored and discussed based on modelling of the current farming systems: 1) Can smallholder farmers benefit from keeping organic dairy cattle, and under which conditions can it be viable, given the current challenges? 2) How can the dairy production be integrated into the farm and create synergy with the different farm elements? 3) What would need to change if their milk were to become certified organic, and farmers had to comply with organic principles and standards for dairy farming?

2. Material and methods

2.1. Project site and framework

This article is based on studies which were part of the project 'Productivity and Growth in Organic Value-Chains' (ProGrOV), which built on a number of coordinated studies on certified organic cash crop farms, each focusing on a specific aspect/challenge as defined in a dialogue with stakeholders. The individual studies are linked in a farming systems and value chain approach in so far as they are carried out partly on the same sample of farms, and the studies cover aspects from soil and crop sciences (soil quality, nutrients and pest management) and animal science (feeding and health management) to markets and governance of the value chain. Two PhD studies were conducted in Kenya and Uganda, respectively, to understand examples of organic production systems in both countries. One MSc study was carried through in Uganda, with the main emphasis on integration of pineapple production and dairy cattle in terms of nutrient flow (Kiggundu, 2015; Kiggundu et al., 2014; Odhong, 2014). The current situations in the two farming systems are described in Table 1, based on these references.

2.2. Research approach: Farming systems modelling

The research approach in this article is based on estimations of the cash and nutrient flows on models of farms representing typical (albeit not necessarily statistically representative) organic mixed farming systems in the regions in focus following a method applied previously for modelling smallholder dairy farming in East Africa (Mubiru et al., 2007; Nanyeenya et al., 2008). This implies a process where the model farms are described as realistically as possible in terms of resources available (land, livestock), production form (cash crops, livestock products), inputs necessary to achieve this production and outputs (kg milk, harvested yields) etc. This quantification is based on selected figures from actual research studies, carried out in the study sites (illustrated in Figs. 1 and 2; Odhong, 2014; Kiggundu et al., 2014; Nalubwama et al., 2016b), and other relevant literature on e.g. the relation between feed level and milk yield. The relevant physical flows in the base line models are subsequently transformed into nutrient and cash flows using table values and specific recordings at the project sites (Mubiru et al., 2011). Thus, we selected and modelled two typical but different farms in Kenya and Uganda, denoted “model farms”, based on as much data as was available through the aforementioned studies and their sub-studies, supplemented with relevant data from literature. Based on these “baseline” model farms, hypothetical changes in farm management and its changes in internal resource use, inputs and production are estimated together with the potential consequences for cash and nutrient flow.

To engage in a qualified discussion on future perspectives for conversion into organic dairy cattle farming, we outlined one future scenario for each farm type. These two scenarios are based on a combination of (imagined) options to 1) involve surrounding grazing areas, 2) involve local communities in feed production, 3) get a premium prize for milk sold as certified organic, 4) improve general animal, health and herd management, and 5) improve the nutrient flow between the different farm enterprises. These five identified options for changing the dairy production from each farm type's baseline were included in the calculations of future potential scenarios, using figures from the mentioned studies in combination with literature sources from East Africa, preferably the same regions as where the studies took place. The estimates are based on information from the on-farm studies in the ProGrOV study, as well as literature, to identify development options. This section therefore includes motivations for some of the estimates, which we use to create future scenarios. These future scenarios can take different shapes, and farmers can exploit different context relevant possibilities for integrating dairy cattle in their certified organic farms.

2.3. Data collection, processing and analysis

The farming system models used here are based on the aforementioned two PhD studies and one MSc study, all of which included cross-sectional questionnaire semi-structured surveys (and some observations in the Kenyan study) of smallholder farms with animals and certified organic crop enterprises. The Kenyan PhD study also included a longitudinal study of the dairy production on organic farms (Odhong, 2014), and a number of smaller experiments with helminth control. Feeding trials with pineapple residuals as silage or fresh feed was tested on smallholder farms in Uganda, and results of these studies are also used in this article (Kiggundu, 2015; Kiggundu et al., 2014;

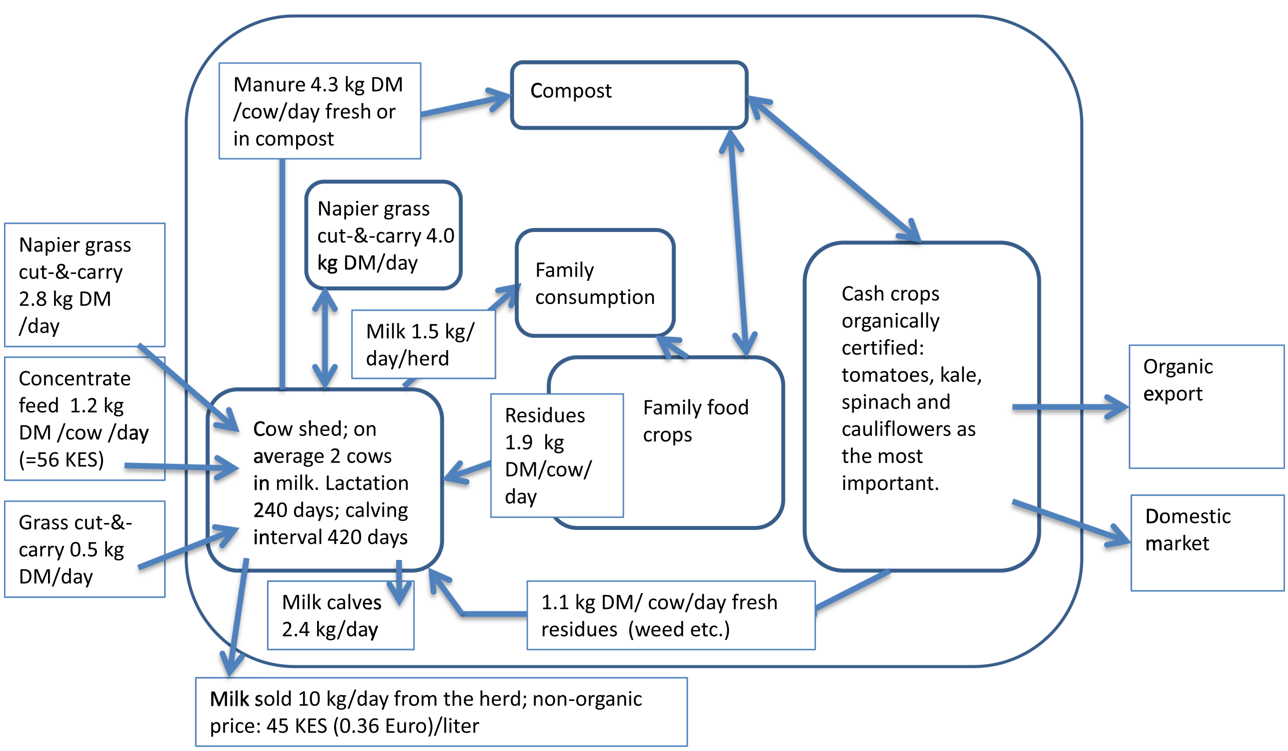

Fig. 1. A model of the current situation regarding nutrient and economic flow of a Kenyan zero-grazing dairy herd with Holstein Friesian cows and milk production for the commercial market and certified organic vegetable and crop production. The model is based on data collected 2012–2014 in Kajiado and Kiambu counties (Odhong, 2014), and the estimate about manure DM/cow/day is based on literature.

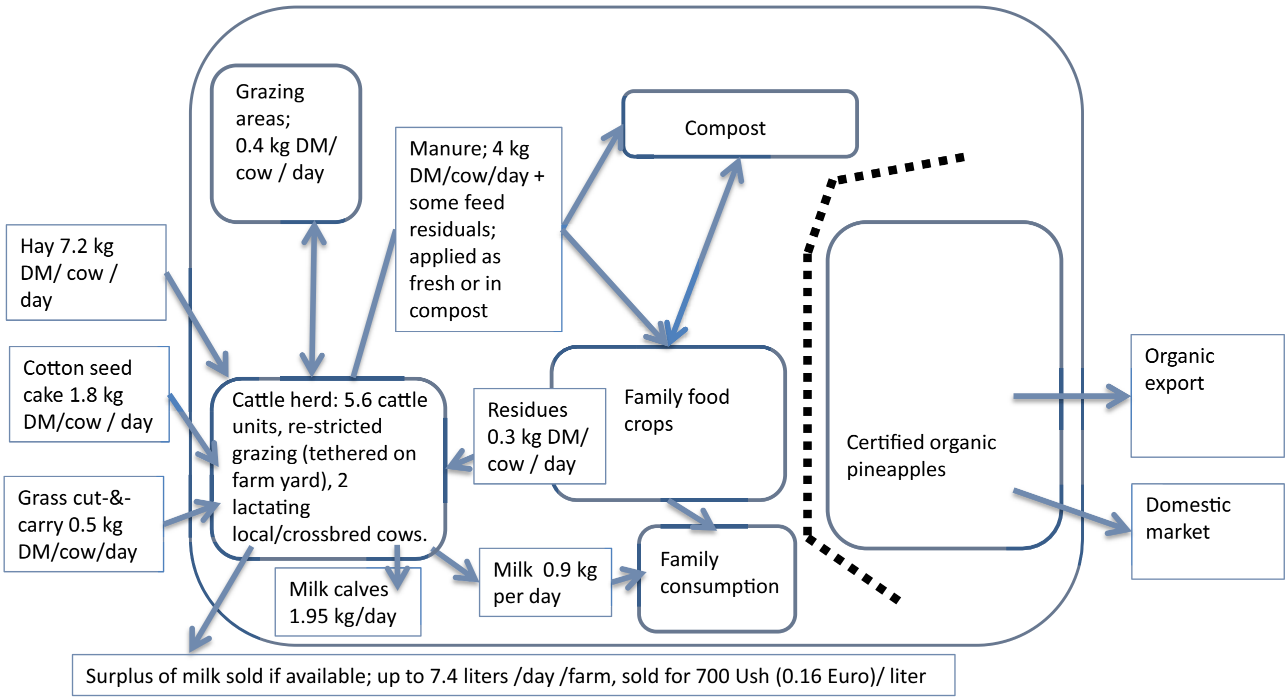

Fig. 2. A model showing the current situation regarding nutrient and economic flow of a Ugandan smallholder farm with certified organic pineapple production (often on distant land, which is why there is a dotted line within the farming system frame), and milk production for home consumption and sale of surplus. The model is based on studies during 2012–2014 in Luwero and Kayunga districts (Kiggundu, 2015; Nalubwama, 2018), and the estimate about manure DM/cow/day is based on literature.

Nalubwama, 2018; Odhong et al., 2015). The PhD and MSc studies all included 2–3 smaller studies, and up to 55 (Kenya) and 90 (Uganda) farms were involved in cross-sectional studies. From these, farms were selected to a more detailed longitudinal study with 24 respectively 30 farms participated from Kenya and Uganda. They represented the range of typical farms in the area, but ex- and inclusion of farms was mainly based on the PhD students' judgement that data from selected farms was reliable. In both countries, cows calved all year round. Lactation number ranged from 1–4. The participating farms were followed relatively closely in Kenya over a 8 month period, including milk recordings from 33 cows, and much data can be claimed quite precise and reliable. In Uganda, only the milk yield was recorded systematically from 44 cows, over a period of 12 months (Nalubwama et al., 2016b).

The Kenyan herds were generally more commercially oriented than the Ugandan herds in this study, and therefore recorded more data themselves, e.g. veterinary and breeding costs. Due to poor record keeping systems on the Ugandan farms, some of the parameters were derived from external literature sources (Mubiru et al., 2007, 2011), while other were estimated based on farmer questionnaires.

The farmers' options and challenges for converting the different farm types to organic production involved identifying the farmers' own perceptions of challenges and options, and assessing by modelling possible feeding and health management within organic regulation and the resulting land use and milk yields (using standard feed to milk conversion factors for different breeds in East Africa). Moreover, the results, seen in terms of cash crop production and farm economics, were estimated partly with background in other studies within the ProGrOV project (Kwikiriza et al., 2016, 2018).

Some figures and assumptions are based on estimates and literature, since systematic data collection was not possible to conduct in the studies. For example, although milk yield/ cow/day was drawn from farm surveys, the amount fed to calves was not possible to measure in Uganda, since the calves were allowed limited suckling. In the Kenyan study, produced milk was recorded at each milking. In the Ugandan longitudinal study, the calves suckled after morning milking, so only the milk, which the farmer milked out, was recorded at each milking. During the modelling process, we attempted to suggest feed rations sufficient for maintaining milk yields before and after conversion to organic milk production, based on the range of commonly reported feed stuffs in the studies in the ProGrOV project, supplemented with literature regarding amounts and nutrient content.

3. Results and discussion

3.1. *Characterising two current smallholder farming systems*

The selected model farms (one in Kenya and one in Uganda) are presented in Table 1, and the current situations are visualised in Figs. 1 and 2.

As shown in Fig. 2, there is a complete separation in the selected Ugandan model farm between certified organic pineapple production, which on 12 out of the 30 participating farms took place on distant land—that is, more than 500 m from the homestead where the cattle was kept. This made crop rotation strategies and integration of cows on the land for organic pineapple growing difficult for the non-mechanised and resource poor farmers. Furthermore, as can also be seen in Fig. 2, quite a huge amount of feed for the cattle had to be bought in (cotton seed cake, if fed), or taken from roadsides or bought in from neighbors. The lactation period was reported to be in average 150 days, after which time the milk yield due to farmer information was so low that calf was allowed to suckle all remaining milk. As seen from Fig. 1, the current situation in the selected Kenyan smallholder model farm, organic crop production (which could be vegetables for the domestic certified organic market in Nairobi, for examples tomatoes, kale, spinach, cauliflowers or crops such as sugar snaps, fruit or herbs for export) was more integrated with the dairy production. The dairy production was commercial, often based on exotic breeds, higher milk yield and longer lactations.

The current feed rations are based on data collected in the ProGrOV study, and presented in a collected manner in Table 2.

Table 2
The feed rations calculated based on estimates from the studies of Odhong et al. (2015) and Kiggundu (2015).

Feed	Kenyan case Intake Kg DM	Intake kg product	Costs/kg KES	Ugandan case Intake Kg DM	Intake kg product	Costs/kg Ush
Napier grass	6.8	34	2.5			
Green Maize thinnings (from the family food production)	1	2	3.5			
Dry Maize stover (from the family food production)	0.9	0.9	1.5			
Cut grass	0.5	0.7	24			
Weeds (cash crop production)	0.5	3.3	2			
Concentrates	1.2	1.4	40			
Others (residuals from the cash crop production)	0.6	1.1	40			
Natural grass				0.4	2	25
Sweet potato vines				0.15	1	50
Banana peels				0.15	1	25
Cut grass				0.5	2	75
Cotton seed cake				1.8	2	1000
Hay				7.2	8	50
Total/day	11.5	43.4		10.2	16	

The feed rations in the Kenyan as well as Ugandan model farms contained approx. the same amount of grass products, but in Kenya it was mainly napier grass and in Uganda mostly natural grass, as fresh cut grass and hay in both cases. The Kenyan ration includes maize-based by-products of an amount, on which cows are able to produce an average of about 7 kg of milk daily. In the Ugandan model farms, it was estimated that cows of 350 kg are able to produce 5.5 kg milk/day when residuals of potato and bananas were included in the ration.

3.2. Modelling potential future scenarios for organic dairy management

The development scenarios for the Kenyan and Ugandan farms are illustrated in Figs. 3 and 4, respectively, combining the options mentioned above.

In the following, we explore the feasibility and viability of each of the five development options for organic dairy production.

3.2.1. Involving surrounding grazing areas

Organic farming seeks to reach high levels of animal health and welfare, through, among other things, access to naturalness and care in ways, which are appropriate and relevant in each specific context. According to the 'East African organic products standard' (https://law.resource.org/pub/eac/ibr/eas.456.2007.html; accessed 28th July 2018): '*Animals shall have the living conditions and be managed according to their natural behavioural needs*'. Grazing must be characterised as a central behavioural need for ruminants, and access to grazing and walking outdoors, as well as performing social behaviour, fulfils some crucial behavioural needs of cattle. Further to this, smallholder farmers

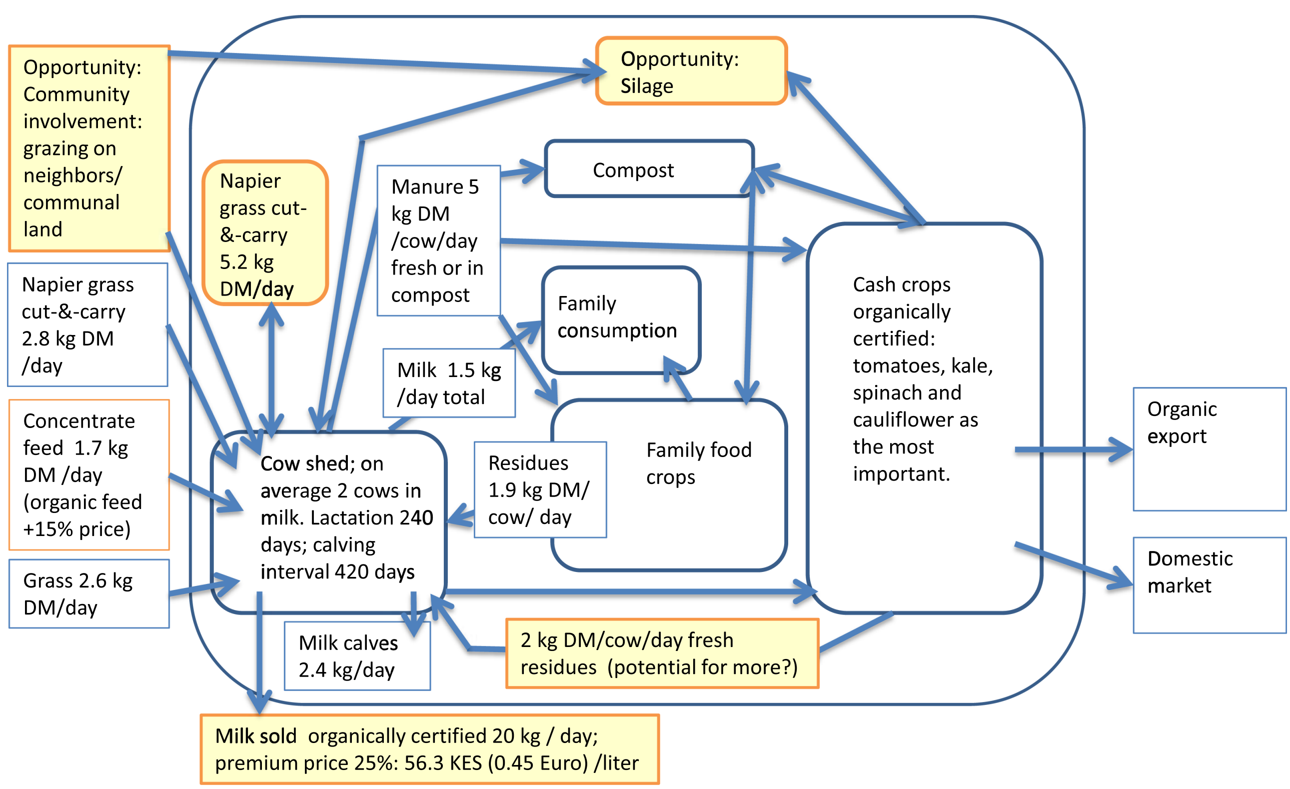

Fig. 3. Modelling the nutrient and economic flow of the Kenyan zero-grazing dairy herd presented in Fig. 1, outlining potential pathways for organic production (yellow boxes): 1) selling the milk as organically certified milk for a premium price, 2) improving feed ration and milk yield, and 3) suggesting community involvement regarding feed and grazing possibilities.

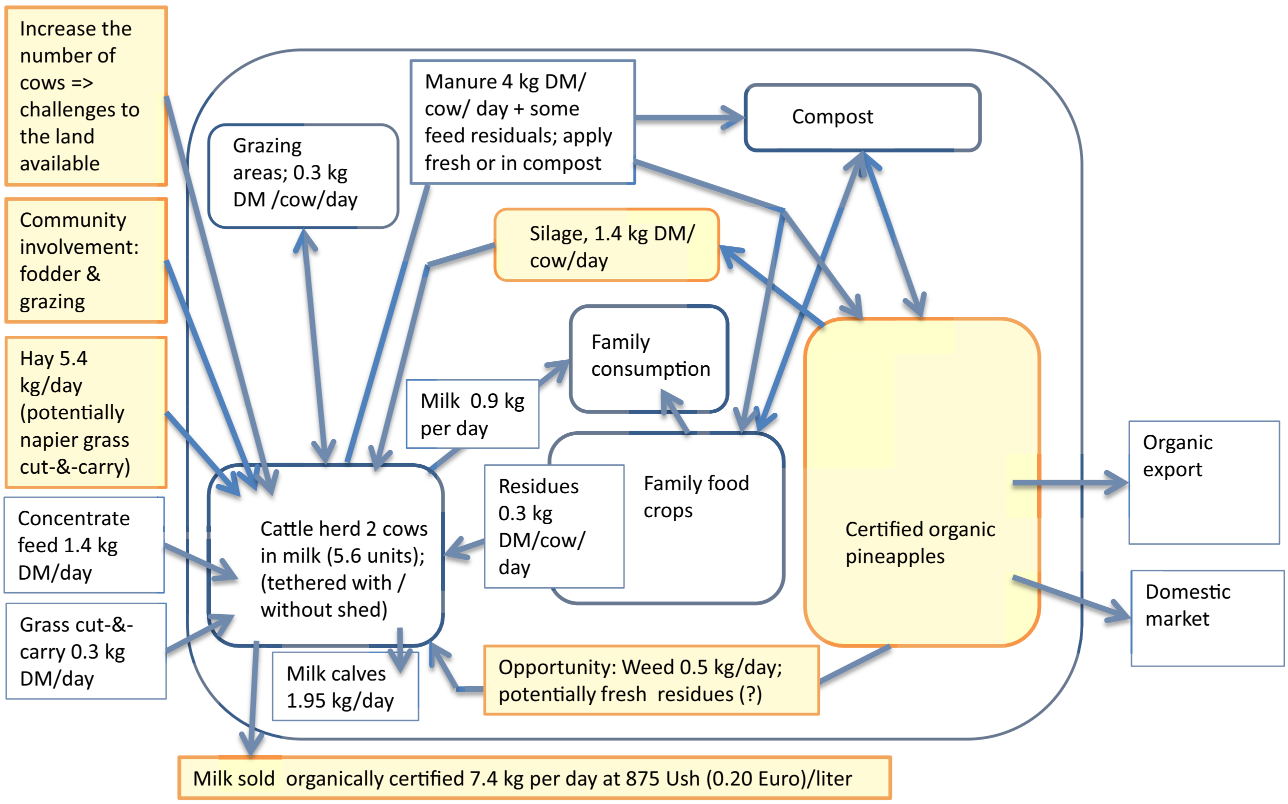

Fig. 4. Modelling the nutrient and economic flow of the Ugandan smallholder farm focusing on development pathways (in yellow boxes): 1) improving the integration of cattle and the cash crop production through feed and manure circulation, 2) Improving the feed ration per day in kg DM = natural grass 0.6; sweet potato vines 0.3; weeds 0.5; pineapple silage 1.4; cotton seed cake 1.4; hay 5.4, allowing the cows to be lactating 300 days, and assuming a calving interval of a year.

must develop strategies to ensure consistent supply of sufficient feed for their dairy cattle.

However, in these particular study areas both in Kenya and Uganda, there was almost no common land for grazing in the neighbourhoods of the farmers. Even if there was, some practical challenges would be linked to this, because the grazing areas must be organic according to the Standards. This may be fulfilled when the cattle are grazing within the same farm, but in many cases, it will require a major effort and cost if involving surrounding grazing areas for certified organic production.

3.2.2. Involving local communities in feed production

In these particular areas, the consistent supply of sufficient feed for the dairy cattle would rely on private farms. The farm sizes in the area were about the same as the ones in the study, and they could potentially engage in feed and hay production. However, they would also need to convert to organic production, and prices needed to be established so that they could make a viable business from producing feed for neighbours. In many East African rural areas, the unemployment rate is often high and household incomes low. Engaging with local communities for production of feed (for example silage and hay), and compost, or exchanging or for renting land from neighbours, could be a good option, given that milk production is profitable enough to carry such engagement.

3.2.3. Getting a premium prize for milk sold as certified organic

During the study there were no existing formalised organic milk markets in Uganda or Kenya, and it was unlikely that the organic farmers could get a premium price for their milk as ‘organic’, and the dairy herds were not subjected to inspection by the organic certifying bodies. However, to imagine future scenarios the possibility for a premium price for organic milk must be considered, because it would be a main incentive for making an effort to convert the herd to organic production and for example take the risks and extra labour of letting the cattle graze part of the day.

In Table 3, we have attempted to calculate the costs and income of the two current situations in Kenya and Uganda, respectively.

As can be seen in the table, dairy production in our modelled farms seems to give a loss for the farmer, both in the current actual situation as well as in a situation with premium prices of dairy products. In a wider study of Ugandan smallholder dairy farms where milk was the primary agricultural commodity. Nanyeenya et al. (2008) and Ndambi et al. (2008) found positive economic results for farms with zero grazing as well as different systems of grazing management. The apparent annual loss from the dairy production on the organic cash crop farms calls for a discussion: Since the farmers continue to keep dairy cattle and are not bankrupt, some of the costs may be perceived differently or be invisible in the daily life of the farmers. For example, the return on investments was estimated on basis of information of the actual farming structures, number of cows, available farmland and tools. We used a quite simple and ‘conventional’ economic analysis, where we quantified all feeds, land, buildings, and equipment in monetary terms, although part of the feeding costs, labour costs, return on investment, costs of buildings/ equipment were not quantified by the farmers themselves. In our calculations, all feed costs were quantified in terms of monetary value, although most farmers regarded feed produce on the farm ‘free of costs’, and did not consider inherited land or own stock as replacement cows as ‘investment’. Feeding costs were calculated on basis of general available market information, since none of the participating farmers had or shared their farm records on this. All in all, our interpretation is that the organic cash crop farmers currently keep dairy cows for home consumption of milk and for reasons of resilience (livestock as capital savings and potential supplementary income if cash crop income fails). However, some costs in Table 3 lead to considerations regarding potential herd management improvements, such as the proportion of feed between lactating and non-lactating cattle. The feeding costs of dry cows and young stock in Kenya are 54% of the costs to feed the lactating cows in Table 3. In Uganda, the feeding

Table 3
Calculations on the farmer's profit or loss with certified organic milk production sold with a premium price, vs. conventionally produced and sold milk on a farm with certified organic crop production, under the circumstances given in Table 1 and Figs. 1 and 2 (the Kenyan and Ugandan current situations, respectively). Feed costs cover all feed. The costs for labour, interest on investment, veterinarian, breeding, land and buildings/equipment were kept fixed in the two scenarios of conventional vs. organic milk. All costs are in Euro.

	Kenyan case (1 Euro = 124 KES)		Ugandan case (1 Euro = 4396 Ush)	
	Conventional, €	Organic, €	Conventional, €	Organic €
Feeding cost/cow/year	1277	1468	444	511
Feeding costs dry period 50%	479	551	400	460
Feeding costs young stock	206	237	115	132
Labour	441	441	417	417
Interest on investment	565	565	105	105
Veterinary cost	71	71	190	190
Breeding costs	41	41	75	75
Costs of land	50	50	40	40
Costs of buildings/ equipment	36	36	5	5
Total costs / year	3164	3459	1791	1935
Income from milk	1332	1665	415	519
Income from animals	733	916	190	238
Total income	2065	2581	605	757
Loss or profit/year	−1101	−879	−1185	−1178

costs of dry cows and youngstock are 116% of the feeding costs to lactating cows, which can be explained by the short lactation periods (150 days) and long calving intervals (420 days). This illustrates that by prolonging the lactation period and shortening the calving intervals, the farmer can significantly improve the farm economy.

Most costs and figures in Table 3 are kept fixed between the two scenarios of organic farms with non-organic versus certified organic dairy cows, which can be questioned. Very little data exists on these matters from East Africa, hence part of the discussion will be based on speculation. The labour costs are estimated relatively high in the Kenyan case in this study compared to e.g., Wambugu et al. (2011), who give far lower labour costs of KES 745 per month per lactating cow. If cattle change from zero grazing to grazing, both feed intake and disease occurrence patterns can change. Choice of breed is therefore regarded as an important element of the farm management system in Ugandan smallholder dairy systems (Mubiru et al., 2007; Nanyeenya et al., 2008). If the animals graze at the roadsides, the grass may be 'free' but of less nutritional value and therefore provide them with less energy, and require the same amount of high quality feed as zero-grazing cows. Daily exercise may take more energy, but may improve claw and leg health, digestion and reproduction, and therefore reduce veterinary costs and disease risks; grazing gives a potential increased exposure to ticks (as discussed below), which will be particularly risky for exotic breeds, and the regular and often preventive use of acaricides is already a huge challenge in organic farming.

Other consequences of keeping certified organic cows could be the costs of a prolonged withdrawal time after medication, as well as certification and inspection costs. Organic principles and regulations encourage generally to enhanced animal health and welfare promoting practices, which could lead to less acute and chronic disease among cows and calves, and this might reduce veterinary costs.

3.2.4. Improving feeding, animal health and herd management

Many assumptions for the creation of future scenarios indicate a potential to improve daily management through, for example, improved reproduction control, disease prevention, hygiene, feed production and higher milk yield. We used the Kenyan case to unfold this potential, because the farmers in the Kenyan studies were commercially oriented in their milk production.

Seasonality of forage is one of the major challenges in meeting nutritional requirements of dairy and dual purpose cattle in Eastern Africa and this is occasioned by frequent droughts (Koech et al., 2016; Lugusa et al., 2016). Fodder production for hay has therefore been regarded as a potential strategy to addressing the problem. Previous studies have shown an increasing trend of acceptance and adoption of forage and its conservation as hay among households in these areas (Manyeki et al., 2015). Therefore, one identified option for improving the feed management on East African dairy farms was production of hay or silage, to extend the period of good available feed into the dry period. In Table 4, this is demonstrated on basis of an actual trial done in the Ugandan PhD study (Nalubwama, 2018) where pineapple silage was included in the feed ration, together with cottonseed cake and hay.

Table 4
Calculations on the farmer's profit or loss with certified organic milk production sold with a premium price, vs. conventionally produced and sold milk on a farm with certified organic crop production. Costs for certification are not included because it is considered to be included in the certification of the entire farm.

	Ugandan scenario with a ration as tested in a trial with pineapple silage; other variables as in Table 1 (1 Euro = 4396 Ush)*)		Ugandan scenario with more feed from the farm, shorter calving intervals and longer lactations (1 Euro = 4396 Ush)**)	
	Conventional, €	Organic €	Conventional, €	Organic €
Feeding cost/cow/year	556	640	457	525
Feeding costs dry period 50%	501	576	49	57
Feeding costs young stock	144	165	52	60
Labour	417	417	182***)	182***)
Return on investments	105	105	48	48
Veterinary cost	190	190	83	83
Breeding costs	75	75	33	33
Costs of land	40	40	17	17
Costs of buildings/ equipment	5	5	5	5
Total costs	2033	2213	926	1009
Income from milk	532	664	472	590
Income from animals	190	238	89	111
Total income	722	902	561	701
Loss or profit/year	−1311	−1311	−365	−308

*) Feed ration in trial (Nalubwama, 2018), kg DM: Hay 9; cottonseed cake 1.9; Pineapple silage 1.5. Milk yield 6kg per cow per day.

**) In this scenario the feed ration per day in kg DM = natural grass 0.6; sweet potato vines 0.3; weeds 0.5; pineapple silage 1.4; cotton seed cake 1.4; hay 5.4. In addition to this, the cows are estimated to be lactating 300 days and have calving intervals of 365 days and yield 5 kg milk per day.

***) The labour cost is calculated due to number of animals, and fewer cattle are needed on the farm as the lactation period increases.

Both pineapple silage and hay allow feeding with good quality feed also in the case of scarcity during the dry season.

In the other scenario in Table 4, more on-farm produced feed was tested, and combined with an assumption that the cows could be lactating 300 days, with calving intervals of 365 days. With longer lactations and shorter calving intervals, less cattle are required on the farm in a scenario, where there should be two lactating cows on the farm at all times, and this makes the milk production much more profitable. This was also shown in Table 3, where feed costs to non-lactating cattle was higher than to the lactating cattle with short lactations and long calving intervals. Kahi et al. (2000) reports lactation length of 320–326 days. The lactation length was calculated to 240 days in Kenya and calving interval 420 days. This means that if two cows should constantly be in lactation, 4.15 cow units would have to be fed. This is in accordance with calculations given by Musalia et al. (2007). When comparing Figs. 1 and 3, we have assumed a potential increase in the milk yield per cow per day of from 7 to 12 kg. This is also due to improved feed and more intense rations, which, in combination with improved management, can result in an average milk yield of 12 kg/day/cow, compared to 7 kg/day/per cow in the current-situation-scenario.

In Table 5, we test several different scenarios, combining this changed feed ration with changes in number of cows on the farm, lactation length, and calving intervals.

As can be seen in Table 5, the increase in milk yield (of course including the increased amount of feed, which needs to be organic if the milk should be sold as organic) creates a tipping point for whether organic certified milk production can create a higher income for the farmer than the milk sold on the non-organic market. In other words, this ‘tipping point’ is created from feed management in combination with a possibility for a premium price. If this premium price is not available, the incentive to feed the cows with organic feed and rear them according to organic standards and principles, probably disappear for the farmers. The feeding strategy used to bring the milk yield from 7 to 12 l consist of better quality feed for a longer time, thereby prolonging the lactation, and shortening the calving intervals. The combination of these strategies contribute to even higher revenues for the organic production. In the study area, intensive milk production and herds with high milk yields (15–20 l/day/cow) are already established. Unpublished data from the PhD study in Kenya showed a peak yield of 18 l milk/cow/day, which decreased to 6–8 l/cow/day, which supports the assumptions that 12 l/cow/day is reachable with the genetic potential in the study farms. Gachuiri (2018) and Njarui et al. (2016) discussed the importance of the more stable provision of good quality feed for keeping a stable milk yield under Kenyan smallholder conditions. Njarui et al. (2016) found a mean milk production of 11.8 l/cow/day with a STD of ± 8.5 for 122 herds in the central highlands, where the studies used in this article took place.

3.2.5. Improving the nutrient flow between the different farm enterprises

As explored above, a premium price for organic milk may be a major incentive for farmers with organically certified production to convert the dairy cows to organic standards. Another important incentive is inherent in the organic farming systems thinking itself: Organic farming is based on ecological cycles. Local and on-farm resource circulation and closed cycles could improve nutrient use efficiency especially Nitrogen availability (Mubiru et al., 2011), soil fertility and crop diversification. Synergy and integration between the different crops and animals on the farm may lead to better overall output and coherence at farm level, e.g., when applying a diversified production of organically certified cash crops in combination with dairy production and family food production. However, we observed a complete disconnection between the dairy cows and the certified organic production, especially at the Ugandan pineapple farms. Better integration could potentially benefit both animals—for example, improved feed in the form of pineapple peelings (and silage partly based on pineapples)–and soil (through compost and manure, although there was an imbalance between number of cattle and land area for pineapple or other crop production).

4. Final discussion

The big question after having learnt from Ugandan and Kenyan smallholder farms and farmers how they manage their cattle as a more-or-less separate enterprise of their farm, is whether East African smallholder farmers can benefit from keeping organic dairy cattle, and under which conditions it can be viable, given the current challenges?

The main reason for zero grazing of the HF cows in the Kenyan study was the fact that grazing can be risky especially for exotic cattle, as they are less resistant to tick borne disease (Rubaire-Akiiki et al., 2004, 2006). Some of the grazing areas in East Africa are common grazing areas, and all cattle must be equally free of diseases and other risks. Using outdoor exercise areas in combination with cut-and-carry-feed is questionable in relation to the organic standards and intentions, since the cattle are not grazing there. There are options for use of herbs for tick control (e.g.,. phytolacca and tephrosia), but they are only anecdotally described in relation to local breeds. Some studies describe options for using herbs for helminth control in grazing systems, including a claimed effect of the tannins in pineapple silage or fresh pineapple residuals. To meet some of the disease challenges, especially those concerning tick borne diseases, the issue of breeds is a major area of interest for the future development. In organic animal production, breeding should not focus on increased milk production only, but also other important traits required to meet the health and welfare needs of the animal in smallholder systems, such as diseases, adaptation to the local environment and utilization of available feed resources. If organic milk production should be partly based on grazing cattle, and with minimum risk for vector-borne diseases, it seems necessary to focus on breeding of crossbreeds with a high level of disease resistance, and yet a milk yield which allows the farmers to sell a certain amount of milk, which can ensure the viability of the milk production. According to

Table 5
Revenues for conventional and organic Kenyan herds, illustrated by changing the number of lactations days, calving interval, number of cows and yield per day (through changed feed ration as explained in the footnote). Other variables are kept fixed on the same level as they were in Tables 1 and 3.

	Scenario	Lactation days	Calving interval, days	Yield kg/day	No. of cows in the herd (in milk)	Conventional revenues, €	Organic revenues, €
1	Current status (CS; Table 3)	240	420	7	3.5 (2)	−1101	−879
2	Lactation days ↑ Calving interval ↓	300	365	7	2.4 (2)	−464	−210
3	Double no. of cows	240	420	7	7 (4)	−1943	−1449
4	Scenarios 2 + 3	300	365	7	4.9 (4)	−669	−110
5	Milk yield 12 kg/cow/day*)	240	420	12	3.5 (2)	−339	130
6	Scenarios 2 + 5	300	365	12	2.4 (2)	413	931
7	Scenarios 3 + 5	240	420	12	7 (4)	418	569
8	Scenarios 2 + 3 + 5	300	365	12	4.9 (4)	1086	2172

*) Feed ration changed to kg DM: napier grass 8; green maize thinning 1; dry maize stover 1; grass 2.6 (cut or grazed, depending on conditions and possibilities); weeds 0.5; concentrate 1.7.

Stear et al. (2001), selection of higher yielding breeds to improve local disease resistance is possible but takes a long time to achieve. In other words: 'improved breeds' - where the improvement is about robustness towards endemic tropical diseases, as much as milk yield – are necessary. The selection within the current Holstein Friesian population can be improved through development and use of an index combining the more important traits including bulk milk yield, helminth, other parasite and mastitis resistance. Such criteria will include ability to withstand stress and resist disease, especially mastitis and parasitic diseases.

Recycling crop residues as feeds for livestock, along with subsequent provision of organic manure as a soil amendment, is an obvious and resource efficient benefit of crop-animal integration (Rahmann and Bohm, 2005; Herrero et al., 2010; Mubiru et al., 2011), that could be better exploited in many cases. Possibilities need to be explored to produce local types of concentrates, which are rich on energy as well as protein. Options to store feed to minimise the fluctuations during the rainy and dry seasons should be further developed. It might be hay as well as silage or haylage, which can even out the feed supply throughout the year, but these may require more land, involvement of local communities. In our future scenario of the model farm in Uganda, we suggested hay and silage as a future potential to store feed to use during the dry period, and in this way ensure a stable milk production. However, it may lead to increased feed costs especially if neighbours should make a viable business from producing it. Furthermore, silage may be costly to produce, pack and store safely. However, it has become common practice for many smallholder farmers in Kenya to purchase hay or silage from other farmers, or produce it themselves. Producing hay and silage – including pineapple silage - is a new technology, which can improve the nutrient and resource circulation on the farm, reduce waste and stabilise milk production, where extension agents play a crucial role. However, in this study, pineapple silage was a research trial, and more research may be necessary to clarify the potentials and risks of using pineapple silage.

Some of the efforts to improve feed production throughout the year may also lead to a generally better integration of the entire farm, such as an effort to integrate multi-purpose trees, e.g., gliricidia or, alternatively, calliandra, which can be used for feed. Possibilities for intercropping and use of trees have not been a focus area in organic farming development in many places in East Africa, even though these techniques could have many other benefits (shade and protection of soil).

Apart from breed and feed, other animal and herd management improvements, such as general hygiene, disease prevention and reproduction may be necessary. The mortality rate for calves was estimated to be 20% in the Kenyan case, which means that if approximately 3 calves are born per herd per year, 2.4 will be raised and either sold (as bull or heifer calves) or go into the herd as milking cows. Makoni et al. (2014) reports lower mortality, Bebe et al. (2003a) reports 15% for heifer calves and 13% for bull calves, as well as 12% for cows. They stated that 25% of the heifer calves died before they reach breeding age. In Kenya, the cows generally lasted for 8.5 years in the herd, which means that the replacement rate is about 0.4 cows per year. Bebe et al. (2003a) gave a replacement rate of 26% of the cows and an age of 72 months for the average cow. The average first- calving age of 33 months is quite comparable to other data – for example, Buaban et al. (2015) and Bebe et al. (2003a) report 33 and 30 month respectively.

From the different scenarios, it appears that longer lactations and shorter calving intervals are crucial for creating a viable dairy production on a farm.

One major challenge for all participating organic farmers in Kenya and Uganda was scarcity of land, which limited the possibilities to produce good quality feed. In the case of the Ugandan farmers, a number of the farms had their pineapple fields distant to the homestead, which made it practically impossible to integrate animals and different types of crops and other farm elements. It was also difficult to offer grazing opportunities or produce feed on land, which was distant from the homestead, and since cows needed daily attention and the milk was used in the household or sold from the farm, it was not an option to bring them to the land with the cash crops. As can be seen in Table 1, the total farmed area was up to 7–8 acres, which also meant that the few cattle could not produce manure enough for the entire farm, including the cash crops. We suggested increased involvement of the surrounding communities, which could mutually benefit all. In addition, possibilities such as use of trees and further diversification of crops might be context specific improvements. In this way, dairy production would be integrated into the farm, creating synergy with the different farm elements, depending on the organization of the farm.

We also explored the possibilities of marketing organically certified milk. Of course, an absolute precondition for this would be the establishment of local markets and consumer interest, as well as willingness to pay premium price for dairy products. The proximity to, e.g., urban centers or other markets, including processing plants, would matter to each individual farmer. However, the viability of 'organic (certified) milk' seemed very doubtful especially for the Ugandan farmers, who had few low-yielding cows with short lactations, hence periods where no milk was produced at the farm. Previous studies in other areas of Uganda, where smallholder milk production is more market oriented, demonstrated a potential for intensification based on improved use of local resources and other practices compatible with organic principles (Mubiru et al., 2007; Nanyeenya et al., 2008).

Certification costs, required changes to meet the organic regulations (*e.g.*, organic feed and possibilities to graze), and general management improvements (which would benefit the farmer under all circumstances, but could be difficult to implement at once) would create financial and resource challenges.

How can the institutional framework around the organic dairy farm potentially be improved? As mentioned in the introduction, there are potential challenges in finding sufficient and relevant guidance on what can be characterized as 'organic livestock production' in the current East African organic standards. Whether based on local standards, or those set by export markets, certified organic farming is practiced in about 130 tropical countries on 37.2 million hectares of agricultural land (Willer, 2011). Animals make up a very small percentage (Chander et al., 2011), and are mostly mentioned in relation to grassland.

Will it be relevant for farmers and dairy companies to aim at an organic milk market in East Africa? In Africa, Asia and Latin America, the consumption of milk and milk products has increased over the past decade (Buerkert and Schlecht, 2012). The global consumption of animal products is a hot topic in the discussion of mitigating climate change, and a good deal of research points to the necessity of reducing the overall production of animal products. However, the consumption of animal products is extremely unevenly distributed between regions of the world, and in the current situation, tropical countries often import dairy products to meet increasing demand for milk and other products, especially in urban areas. Furthermore, some tropical countries have special governmental or NGO programmes to increase the number of dairy animals aimed at improving diets and alleviating poverty (FAO, 2016; Mwebaze and Kjaer, 2013; EADD, 2014; Scairi et al., 2013; Ndambi, 2008; RDCPII, 2015; Lipita et al., 2015). Much 'aid' from the global north to e.g., African countries target largescale producers and Staal et al. (2008) advised policy-makers and development investors that growing demand should be used as a mechanism to help continue and sustain smallholder dairy enterprises. Goodison (2015) pointed to the risk of undermining the development of the local dairy industry. In the light of this, local organic production of milk (and other animal products) could be very relevant to creating support for governments, because it adds to farmer families' livelihoods and more healthy diets. In this light, it seems important to build up a more human and animal friendly dairy production, which is well-integrated with other production and is independent of imported feed, medicines and other inputs.

Certification is in some cases organised exclusively around the cash crops directed towards international markets. If certification included the whole farm at all times – no matter whether the individual parts are marketed or not–it would stimulate farm integration and diversification, and the understanding of the system as a whole, and which characterize the organic farming approach. The question here is whether a third-party certification is necessary at all cases, or whether a whole-system approach can be ensured through other forms of certification, like Participatory Guarantee Systems, where groups of farmers support each other through common learning and perhaps common marketing.

5. Conclusion

There are good possibilities for better integration of animals into certified organic crop production in the local recirculation of feed and manure, although the benefits can be limited in cases where a small number of cattle does not match the proportionally larger area of cash crop production. Involvement of local communities in feed production and use of grazing areas seems to be a good option to the mutual benefit of both.

If certified organic smallholder farms should diversify their income through sale of organic milk, they will need a secure market. Depending on the cost of certification, they will only benefit from it if they can produce milk all year round at a scale, which allows them to benefit from the effort to give animals organic feed, including the establishment of grazing and local feed production, which comply with organic standards. In this study, a potential for benefitting from conversion to organic production was identified in one case (the Kenyan case), especially if conversion could be combined with better feed and management. In the other case (the Ugandan case) the milk production was so low and unstable over the year that this did not seem to be an option without a profound system change.

Outdoor stay and grazing continue to challenge many smallholder milk producers, especially with Holstein Friesian types of cows. To meet this challenge, a significant effort is needed to develop breeds with more robustness towards vector borne diseases. In addition, many smallholders do not have land holdings large enough for grazing around their homestead, where the animals live.

Organic standards have largely ignored animals so far, and need to be improved and more precise, especially on requirements for grazing areas and feed for animals. To improve crop-animal integration and the focus on the systems advantages of farms, certification should comprise whole farms including the animals, and not only crops for export.

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