

Project Proposal: The Gambia Goat Dairy

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1 **PROJECT SUMMARY**

2 The Sulayman Junkung General Hospital (SJGH) is located in the town of Bwiam in
3 western Gambia. SJGH and the Gambia National Nutrition Agency (NaNA) identify wasting and
4 stunting due to undernutrition as a major public health concern in The Gambia, and healthcare
5 centers are often limited in their ability to treat malnourishment due to insufficient funding
6 hindering medication access. Given that low protein consumption is a major determinant of
7 undernourishment, many Gambian organizations have emphasized the need for accessible, high
8 quality protein. This proposal describes a goat dairy project to be implemented through the
9 multilateral involvement of Gambian government organizations, private businesses, non-
10 government organizations (NGOs), non-profit organizations and academic institutions to combat
11 the prevalence of undernutrition in The Gambia. The Gambia Goat Dairy (GGD) will be a
12 carefully managed operation through SJGH that generates a sustainable source of revenue for the
13 hospital while creating a local supply of safe, affordable protein.

14 Here, we propose a number of interventions targeting goat breeding, husbandry, dairy
15 processing, and product marketing to ensure long term self-sufficiency of GGD. The nature and
16 scope of the need for protein is defined, and the role of a goat dairy in addressing that need is
17 illuminated. A detailed description of implementation procedures is provided, and valuable
18 community assets are identified. Avenues of revenue generation are assessed, and marketing and
19 pricing strategies are discussed in the context of GGD's ultimate goals. A three-year budget with
20 capital expenditures and yearly costs is drawn, and the long term profitability of the dairy is
21 modeled. Methods of ensuring financial and environmental sustainability are described. Potential
22 challenges are discussed at length and solutions to these issues are proposed. Measures of
23 success are also established to ensure project accountability.

24 This report describes the feasibility, sustainability, and profitability of GGD. With
25 adequate support from funding organizations, start-up costs can be secured and social impact can
26 quickly be realized.

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1 **COUNTRY SPECIFICS AND NEED**

2 **Country Background**

3 The Gambia, located on the West Coast of Africa is the smallest country in mainland
4 Africa, measuring 11,295 km² (Marshall et al. 2011). The Gambia forms is nearly entirely
5 surrounded by Senegal, with the River Gambia running the length of the country and dividing it
6 into North and South banks. The Gambia experiences a five-month rainy season (mid June-mid
7 October) and a seven-month dry season, reaching annual rainfall levels of 900-1400 mm,
8 depending on location (Frenken 2005).

9 The Gambia's economy is largely based on agriculture, with 77% of the labor force
10 engaging in agriculture (Secka 2016). The service, transit, and tourism sectors also contribute
11 significantly to the overall gross domestic product (GDP). Peanut products, fish, cotton and
12 palm kernels are the main exports from The Gambia (Marshall et al. 2011).

13 Five main ethnic groups make up the majority of the population: Mandinka, Fulani,
14 Woolof, Jola, and Serahuleh. English is the official language, while each ethnic group has its
15 own language. The dominant religion of The Gambia is Islam, making up 95.7% of the
16 population (Darboe 2004). The literacy rate is 55%, with 64% and 47% of men and women
17 literate, respectively (Hegazi et al. 2010).

18 The Gambia's GDP ranks 213 out of 229 countries, with a GDP per capita of \$1600 USD
19 (Sallah 1990). With over 1.9 million people, The Gambia has the fourth highest population
20 density in Africa, with 128 persons/km² (NaNA 2011). Additionally, The Gambia is
21 experiencing tremendous population growth, with 38% of the population below the age of 15
22 (NaNA 2011). Together, these facts illuminate a necessity for strategic use of land resources
23 including intensification of the agriculture sector.

24

25 **Malnutrition**

26 The Gambia National Nutrition Agency (NaNA) reports a current acute malnutrition
27 prevalence in The Gambia of 10.3%, exceeding the threshold of an epidemic as defined by the
28 World Health Organization (WHO) (Waterlow 1972, NaNA 2015). In The Gambia, 17.4% of
29 children under age five are moderately underweight and 4.2% are classified as severely
30 underweight (UNICEF 2012). The same study shows that 23.4% and 6.8 % of children are
31 moderately and severely stunted, respectively, while 9.5% and 2.1% are moderately and severely

1 wasting, respectively (UNICEF 2012). By comparison, less than 5% of children in the United
2 States are stunted (UNICEF 2015). The stunting data is of particular interest, as it reflects
3 “chronic malnutrition as a result of failure to receive adequate nutrition over a long period and
4 recurrent or chronic illness” (UNICEF 2012). Additionally, to assess childhood malnutrition,
5 birth weight statistics can be evaluated to indicate health and nutrition status of the mother, and
6 to predict the infant’s chances of survival, growth, long-term health and psycho-social
7 development (UNICEF 2012). Of the 50.8% of Gambian infants whom were weighed at birth in
8 this study, 10.2% were low birth weight infants (<2.5kg). While NaNA lacks current data
9 specifically reporting protein consumption by children, their executive board claims that animal
10 protein consumption is severely lacking due to both social and economic factors. Namely,
11 animal protein afforded by a family is prepared and presented to the household in a shared dish,
12 where protein priority tends to favor adults. Children typically do not eat separate portions to
13 ensure their nutritional needs are met, and NaNA officials confirm that complimentary foods are
14 not given at all nor with the proper frequency, leading to micronutrient deficiencies. Although
15 more studies are needed to quantify the exact protein deficiencies experienced in children across
16 different regions of The Gambia and in different socio-economic classes, the current body of
17 knowledge clearly indicates a need for increased accessibility of high quality animal protein
18 sources for children and the community as a whole.

19

20 **Dairy Economics and Industry Statistics**

21 The livestock sector contributes 8% of the GDP of The Gambia (Somda et al. 2003).
22 While the majority of Gambians engage in some form of livestock production, only 13% of cattle
23 owners sell milk (Marshall et al. 2011). When asked about production objectives, 97.3% of
24 cattle owners ranked meat production first, followed by draft power at 19.2% and milk
25 production at 16.4% partaking in each objective (Somda et al. 2003). Domestic milk production
26 in The Gambia is unequivocally small, and fails to meet consumer demand (Somda et al. 2003).
27 The same survey found that “more than 90% of the interviewed individuals consume dairy
28 products, whether they are men or women, basic or highly educated.” As such, the majority of
29 milk products sold in The Gambia are imported, and largely sold through super-markets and
30 shops (Somda et al. 2003). Domestic dairy products, on the other hand, are sold through the so-
31 called informal sector via sales at the farm gate (74.4%), at market places (15.6%) or at both

1 (2.2%) (Somda et al. 2003). Consumers generally prefer cow's milk, with 2-2.5% of sampled
2 individuals in this same study claimed preference for goat's milk. This study also found sour
3 milk to be the most preferred product (33%), with imported skimmed milk preferred by 11% of
4 consumers surveyed. Raw fresh milk and cream are also present milk in the informal sector. The
5 consumption of locally made yoghurt is slightly higher than the imported one, both in terms of
6 the proportion of households (4%) and the quantity consumed on a monthly basis (8 kg/month)
7 (Somda et al. 2003). There is little information available on the preference of cheese as a dairy
8 product in The Gambia.

9 The widespread sale of imported dairy products indicates an unmet market demand and
10 role for domestic milk production in The Gambia. The lack of formal, domestic milk marketing
11 can be attributed to several constraints including equipment inadequacy, resource and
12 technological limitations, and lack of transportation and financial support (Somda et al. 2003).
13 The development of a domestic dairy sector would be valuable to both smallholder farmers
14 looking to expand their family income and to the economy of The Gambia.

15

16 **Livestock Statistics—Prevalence of Goat Ownership and Productivity Information**

17 Throughout The Gambia, 67% of households own livestock, which provide an overall
18 total of 6.5% of total household income (Marshall et al. 2011). Households report keeping
19 livestock as a form of savings, insurance, and income (Marshall et al. 2011). While the majority
20 of households keep livestock capable of milk production, few actually use their animals for this
21 activity, contributing in part to the low percent of household income achieved by husbandry
22 (Somda et al. 2004). Cattle make up the majority of the dairy sector, and produce an average of
23 0.7 liters and 1.7 liters of milk per day in the dry and rainy seasons, respectively (Marshall et al.
24 2011). These numbers pale in comparison to milk production achieved by cattle in other areas of
25 the world, for a multitude of reasons including a lack of adequate nutrition and uncontrolled
26 rather than strategic breeding. For example, the average milk production of a dairy cow in the
27 United States is 22,400 lbs a year, or roughly 27 liters per day (USDA 2016). Goats are even less
28 frequently used for milk production due to their presently lower milk yields. Thus, strategies
29 that improve productivity of Gambian livestock could tremendously benefit the majority of
30 Gambian farmers.

31

1 **The Role of Women in Livestock Ownership**

2 Women make up 67% of goat owners, possessing more goats than men do in many
3 instances (Marshall et al. 2011). Furthermore, in 80% of livestock owning households, women
4 were the owners of goats (Marshall et al. 2011). Women are also the predominant sellers of
5 milk, making up 81.69% of sellers (Somda et al. 2003). Accordingly, any strategies working to
6 improve livestock productivity must actively involve women. Livestock sector improvements
7 should empower women through the expansion of productive markets, specifically those in
8 which they already play a significant role.

9

10 **Environmental Concerns**

11 The destruction of natural habitats has been identified as the major driver of biodiversity
12 loss in The Gambia and worldwide (Loreau 2010, DPWM 2014). Two specific means by which
13 habitats are lost in The Gambia include bush fire and deforestation (DPWM 2014). Farmers
14 seeking to dispose of crop residues after harvest frequently start bush fires that lose control and
15 cause the destruction of vast areas of habitat, resulting in a significant loss of natural diversity
16 (DPWM 2014). Such fires are started by farmers as a means of clearing land and reducing the
17 availability of residues that attract roaming livestock, which unknowingly trample crops in
18 pursuit of feed, especially in the dry season (ITC 2016). Deforestation is equally prevalent,
19 mainly for the creation of pasture for livestock and as a means of extracting timber for use as a
20 building material and source of charcoal (DPWM 2014). Deforestation is a major contributor to
21 global climate change as it directly removes a natural carbon sink, and contributes to biodiversity
22 loss through habitat destruction (Pan et al. 2011).

23 The rapid growth of Gambia's human population also lends to an increase in roaming
24 livestock that frequently employ corridors through bush to reach pasture or sources of water (ITC
25 2016). These corridors further fragment natural habitats, leading to harmful edge effects and
26 mitigating the ability for larger game to roam as necessary (Laurance and Yensen 1991, Murcia
27 1995, Woodroffe and Ginsberg 1998, Hobbs 2001, DPWM 2014). Furthermore, such livestock
28 corridors provide avenues that allow for the extraction of timber and bamboo from previously
29 untouched areas (DPWM 2014).

30

1 **Community-Defined Need**

2 The Chief Executive Officer (CEO) of SJGH, Kebba Badgie, recognized malnutrition as
3 a serious issue in his hospital and the community at large. He imagined a role for a goat dairy in
4 providing milk to malnourished hospital patients to help improve their nutritional status. He
5 identified a goat dairy as an operation with the potential to provide affordable, safe and locally
6 sourced milk products to the community as a means of preventing malnutrition on the family
7 level.

8 Dr. Dansul, the head physician of the malnutrition ward at SJGH, stressed that there was
9 a greater need for antibiotics and vitamins compared to the need for milk for malnourished
10 patients. Insufficient funding, to provide these products, is the primary issue. In addition, NaNA
11 provides a national malnutrition treatment protocol, which does not include the use of goat milk
12 as a feeding supplement for severely malnourished patients. Dr. Dansul's recommendation is to
13 use the milk produced by a dairy for patients who are undernourished. The use of dairy as a
14 nutritious protein source for undernourished patients going home could be discussed with
15 mothers and families of patients, to improve overall nutrition of both the patient and their family
16 members.

17 With Dr. Dansul's input in mind, the overall proposal was modified and expanded. A
18 goat dairy can provide the community accessible dairy products at a fair price, and its revenue
19 will be directed to the SJGH malnutrition ward. Thus, this project will address malnutrition in
20 hospital patients directly by providing revenue to purchase needed vaccines and antibiotics but
21 also in the community at large by making high quality milk products accessible. While not yet
22 available, statistics on antibiotic and vitamin demand usage from the malnutrition ward will be
23 useful in determining a baseline need for the ward that can then be compared to improvements as
24 a means of measuring success.

25

26 **ADRESSING THE NEED**

27 To address the aforementioned needs, we propose the construction of The Gambia Goat
28 Dairy (GGD) at SJGH.

29

1 **Improving Nutrition with Goat Milk**

2 The unique composition of goat milk in terms of lipids, amino acids, and minerals make
3 it a potential nutritional supplement and medical treatment for children with various medical
4 conditions, namely infant malnutrition and milk allergies (Haenlein 2004). Recent scientific
5 studies have characterized the medical benefits of goat milk, which had long been anecdotally
6 identified (Haenlein 1992, Park 1994, Haenlein 2004, Chilliard et al. 2007, Park 2012). The
7 average amino acid composition of goat milk is higher than cow milk in the following 6 of the 10
8 essential amino acids: threonine, isoleucine, lysine, cystine, tyrosine, valine (Haenlein 2004).
9 Goat milk contains significantly more calcium, phosphorus and iron compared to cow milk
10 (Belewu et al. 2009). The casein micelles of goat milk have a lower stabilization rate compared
11 to cow milk, leading to less clustering of fat globules, smaller curd formation and easier
12 digestibility (Haenlein 2004). The composition of specific casein molecules in goat milk
13 produces less allergic reactions than cow's milk casein, making goat dairy digestible for
14 individuals with allergies to cow milk (Haenlein 2004). Additionally, goat milk has slightly
15 lower lactose levels than cow milk, such that some lactose intolerant individuals can digest it.
16 Lastly, goat milk contains higher capric, caprylic acids and medium chain triglycerides, each of
17 which have become established medical treatments for a variety of diseases, including non-
18 thriftiness of children and infant malnutrition (Haenlein 2004).

19 Due to these and other advantages of goat milk, its medical role in treating and
20 preventing malnutrition is slowly being realized. Studies on the potential of goat milk
21 recommend it as an alternative to cow milk in treating undernourished children, after seeing that
22 children drinking goat milk outgained children drinking cow milk by 9% over a two week trial
23 period (Haenlein 2004). It has also been shown that "the adult daily dietary nutrient
24 recommendations for essential amino acids would be met equally or exceeded by a 0.5L goat
25 milk consumption compared to cow milk" (Haenlein 2004). These facts together indicate a role
26 for affordable goat milk in improving the nutrition of children in The Gambia.

27

28 **Strengthening the Gambian Economy**

29 The vast majority of dairy products available for purchase in The Gambia are imported
30 from Western Europe (Somda et al. 2003). This indicates local demand for dairy that is not being
31 met by current agricultural operations, and represents a large burden on the Gambian economy.

1 A reduction of import reliance by increasing the productive capacity of local dairy farms would
2 therefore strengthen The Gambian economy. While the initial scope of GGD is small, a
3 successful smallholder dairy will serve as a model for replication elsewhere in The Gambia and
4 lead to the eventual reduction of dairy imports.

5

6 **Educating Smallholder Farmers and Promoting Community Wealth**

7 The majority of Gambian households raise livestock as a means of income and savings.
8 Still, many farmers struggle to achieve adequate animal productivity and seek ways to improve
9 upon this (Marshall et al. 2011). In a 2011 study, a total of 64% of households requested
10 information regarding the management of endemic ruminant livestock, indicating a desire to
11 learn techniques to improve animal productivity (Marshall et al. 2011). Through the provision of
12 workshops on animal husbandry, health, and management, GGD can provide this information,
13 allowing local farmers to increase their herd productivity. Regardless of farmers' intention to
14 produce milk or meat, these workshops teach principles to help them increase overall animal
15 productivity and thereby their household income from livestock. By emphasizing the potential
16 market for and importance of dairy through our workshops, local dairy operations can be
17 established and expand. As previously described, the Gambian domestic dairy market is small
18 and has tremendous potential for expansion. If farmers in the Bwiam work with GGD to
19 leverage this market, farmers can increase incomes resulting in an overall expansion of
20 community wealth.

21

22 **Promoting Women's Economic Stability and Status**

23 Women clearly play important roles in raising small ruminants (Marshall et al. 2011). As
24 GGD expands to provide educational workshops to local farmers, women must be recognized for
25 their importance and emphasized during trainings. With the current lack of a goat dairy sector in
26 the Gambia, there is no preconception about what role women can play in the future of this
27 market. Thus, if GGD encourages strong female involvement both in positions of project
28 management and farmer training, the dairy could help women access a new market and improve
29 their independent economic position.

30 Additionally, GGD will work directly with women's empowerment groups in the Gambia
31 to ensure that women are included in the goals of our project. This could manifest as women

1 employed as staff of the dairy, or as Gambian women's organizations helping us lead workshops
2 to ensure their accessibility to female farmers. We believe our educational workshops should
3 emphasize gender equality, to improve the economic and social position of women in
4 agriculture, and will continually emphasize this as a goal of our outreach campaigns.
5

6 **Preserving Gambia's Ecosystems**

7 With the major driver of biodiversity loss in The Gambia identified as habitat loss
8 through bush fires and deforestation, GGD should exist as an enterprise that actively mitigates
9 these factors. As a semi-intensive livestock operation, GGD will use less land per unit of food
10 produced than would an extensive system (Tilman et al. 2002, Foley et al. 2005). As it will be
11 established on developed land within the confines of the hospital rather than fresh pasture or
12 forested land, GGD will exist as a low-impact agricultural establishment. If successful, it will
13 serve as a model for local farmers to adopt and effectively divert agricultural practices from
14 untouched areas. The GGD will prioritize the planting of browsing trees and natural forages for
15 its goats. Browsing trees and natural forages are endemic flora that support a diverse ecosystem
16 of organisms while providing nutritious leaves for goat grazing. This will increase farmland
17 biodiversity by supporting a wider variety of species that can sustain a healthy ecosystem.

18 A more direct impact GGD will have on the promotion of biodiversity will involve the
19 consumption of crop residues. As a semi-intensive system, GGD will be dependent on the
20 purchase of crop residues from local farms that would normally burn these materials. GGD will
21 therefore fulfill a vital role in the mitigation of bush fires by reducing the amount of burnable
22 bush and, instead, converting it into high quality products for consumption by humans. We
23 therefore hope to reduce biodiversity loss as a result of bush fires by purchasing crop residues
24 that would otherwise contribute to such fires.

25 The semi-intensive structure of GGD also eliminates the need for livestock corridors. If
26 successful, GGD's semi-intensive model can be replicated elsewhere as a means of redirecting
27 agriculture away from large expanses of uninhabited land that can subsequently be preserved.
28

29 **Increasing Access to Medication at SJGH**

30 One of the main goals of Gambia Goat Dairy is to support SJGH in malnutrition
31 treatment. To do so, GGD will specifically subsidize the malnutrition ward, which has stated

1 that the dilution of funds to the entire hospital limits their ability to provide proper treatment to
2 malnourished patients. Through this funding, malnourished patients can receive higher quality
3 care while in the hospital, where they can simultaneously learn about the benefits and local
4 accessibility of goat milk as a dietary protein source to help prevent malnourishment in their own
5 and their family's futures. Once this goal is achieved, additional revenue from GGD can be
6 disseminated as subsidies to other needy areas within the hospital.

7

8 **IMPLEMENTATION**

9 Here, we propose a detailed list of procedures necessary for GGD to begin operating.
10 Animal nutrition, a breeding program, proper husbandry practices, veterinary care, farm
11 infrastructure, dairy processing, labor, and community assets are discussed. Each area will need
12 to be critiqued and adjusted as implemented to ensure the longevity of GGD.

13

14 **Nutrition**

15 Improving nutrition for livestock is a critical aspect of increasing animal productivity
16 (Wilson 1982). Dramatic increases in milk and meat production are achieved with a complete,
17 balanced diet (Wilson 1982). In the Gambia, where rainfall dictates feed availability, a detailed
18 feeding regimen including ways to store feed for the dry season, is vital to the health and
19 production of our herd. Currently in The Gambia, 30% of households raising livestock
20 experienced feed shortages in the last 10 years, and very few use cakes or concentrate feeds to
21 supplement their animals (Marshall et al. 2011). As such, N'Dama cattle raised under traditional
22 smallholder mixed farming production systems lose 10-25% of their body weight during the dry
23 season resulting in significant production losses (MoA 2012, Marshall and Dempfle 2013). To
24 address these potential losses in goats raised under similar environmental conditions, we plan to
25 instead employ a semi-intensive production system. This system will involve proper feed
26 storage and management procedures to provide sufficient nutrients and caloric intake to limit dry
27 season weight loss and enhance herd productivity.

28 Each goat will be fed a diet consisting of various levels of basal feeds, crop residues, and
29 supplements, dependent on the life stage and physiology of the group (Njai 2013). The basal diet
30 will vary based on the season. During the dry season, all goats will be given groundnut hay ad
31 libitum and during the rainy season goats will graze freely over our 4.5 acre (1.8 hectare) field

1 consisting of *Panicum maximum* grasses, luceana and moringa trees. The goats will have the
2 ability to graze this field during the dry season, however growth of grasses will be significantly
3 limited. A portion of the pasture will be irrigated to allow for year-long *P. maximum* growth,
4 using rainwater collected and stored during the rainy season. This will supplement groundnut hay
5 as the dry season basal diet.

6 Different groups of goats will receive supplements to support their increased metabolic
7 outputs. These groups include lactating females, late pregnancy females, male stud goats, sick
8 goats, and pre-breeding females. The supplement ration will consist of a concentrate and bran, at
9 an optimized proportion in terms both nutritional value and price. Concentrates available in The
10 Gambia include groundnut cake, sesame cake, and cotton seeds. Brans available include millet,
11 rice and cous. Groundnut cake will be tested periodically for presence of aflatoxin, and the
12 dietary intake of groundnut cake will not exceed 20% as an extra precaution against aflatoxin
13 toxicity. Each physiologic group will receive a specifically formulated amount of supplement to
14 ensure their diet meets their metabolic needs. These amounts and proportions of feeds will be
15 formulated with input from The University of Pennsylvania School of Veterinary Medicine's
16 Center for Animal Health and Productivity.

17 Goats will have free access to mineral blocks. These mineral blocks will consist of salt,
18 oyster shells, cement and water. The blocks will specifically provide calcium and phosphorus, in
19 order to promote healthy bone growth, fertility, and milk production. Trained staff will make
20 these mineral blocks from locally available oyster shells, purchased salt, and cement.

21 Goat kids will be weaned with the incorporation of creep feeding. At 4 weeks of age,
22 goat kids will be introduced to supplements starting at 50g/day and increasing to 100g/day by the
23 time the kid is fully weaned at 2-2.5 months of age. Nevertheless, weaning age is dependent on
24 weight of the goat kid, and all kids should be >8kg when weaned.

25 Feeds will mostly be sourced externally, with purchase of groundnut hay, crop residues,
26 concentrates and bran to supply the needs of the dairy. Purchasing contracts or buying feeds in
27 bulk will help reduce the effect of seasonal price variability of feeds. Additionally, contracts can
28 be drafted between GGD and feed suppliers to specify a yearly set price for a specific amount of
29 feed needed by the dairy. Crop residues will be collected from the hospital garden initiative and
30 local farms to reduce crop waste. Oyster shells used for mineral blocks will be procured from
31 local fishermen on the estuary. *P. maximum*, luceana and moringa will be grown on the farm

1 pastures and irrigated during the dry season to provide the goats with rainy season pasture and
2 browse fodders.

3

4 **Breeding**

5 GGD hopes to maximize the efficiency of the endemic West African Dwarf (WAD)
6 breed by optimizing herd nutrition. GGD will therefore begin by implementing a straight
7 breeding program to maximize the herd's genetic potential. Seventy-five WAD females will be
8 purchased from local markets, having been selected using anatomical measurements as proxies
9 for good health and high production (Coleby 2012). These established proxies must be used as
10 there is no available data on WAD lactation in The Gambia. Does will be bred with WAD bucks
11 who were selected similarly. After kidding, each WAD female will be evaluated for milk
12 production, yields will be carefully recorded, and only the most efficient and productive females
13 and their offspring will be subsequently bred. This scheme will help improve GGD's genetic
14 pool. If milk production exceeds 2L/day/goat after three rounds of straight breeding, the straight
15 breeding scheme will be pursued. However, if the production levels fail to reach 2L/day/goat,
16 GGD will pursue a cross-breeding strategy.

17 The West African Dwarf (WAD) goat is advantageous for its inherent trypanotolerance.
18 "Trypanotolerance in WAD goats has been described as an innate ability to remain productive
19 under trypanosomiasis risk with very low mortality" (Dhollander et al. 2005). Saanen goats, on
20 the other hand, have high genetic potential for milk production but limited disease resistance in
21 tropical conditions of The Gambia. Dhollander and her colleagues also showed that that hybrid
22 offspring of WAD females and Saanen bucks retained some trypanotolerance and increased
23 weight gain. Unpublished data from this study showed the crossbred females had increased milk
24 yields of up to 2.5 L milk/day (ITC 2016).

25 Building off of this study, we aim to cross female WAD with Saanen semen imported
26 from the United States. This requires a population of fit, purebred WAD females to impregnate, a
27 regular supply of high quality purebred Saanen semen for artificial insemination (AI), a trained
28 AI technician, and technical guidelines for staff on breeding scheme management. Semen will
29 be purchased in the US and imported to The Gambia. There is currently no policy restricting the
30 import of livestock genetic material into the Gambia, so limits towards the feasibility of semen
31 importation will occur in cost alone. Major costs include the price of semen and cost of

1 international transport. The Saanen semen will be stored in a semen storage tank requiring liquid
2 nitrogen. Liquid nitrogen will be sourced from the Medical Research Council (MRC) facility in
3 Fajara (Kombos Region).

4 Seventy-five female WAD goats will be hormonally synchronized to control kidding and
5 time of lactation. Trained staff will perform AI when the female WADs are in heat. Female F1
6 offspring from the crosses constitute the primary milking herd, while the male F1 offspring will
7 be castrated to prevent the dilution of trypanotolerant genetics in the Gambian goat population.
8 We aim to have fifty female F1 offspring to initiate our milking herd. Male F1s will be grown to
9 slaughter weight (approximately six months old) then sold for higher prices than their WAD
10 counterparts due to their increased weight gain compared to indigenous WAD (Dhollander et al.
11 2005). Female F1s will be backcrossed to a WAD buck to optimize lactation periods and milk
12 yields. The F2 offspring will be raised for meat and sold when reaching slaughter weight
13 (approximately six months).

14

15 **Husbandry**

16 The GGD herd will be raised in a semi-intensive system; animals will be housed in well-
17 ventilated sheds with access to pasture. Lactating females will be housed separately from
18 weaned kids and males to be sold to market. Stud bucks will be housed in individual sheds.
19 Each group will remain separated from each other but will have free access to fenced in pasture
20 during the day. Goats will be locked inside during the night to prevent theft and predation. Each
21 morning, groups of animals will be released to pasture and enclosures will be cleaned of fecal
22 debris. Each enclosure will be disinfected weekly.

23 Each pasture will have ample water and shade access. Additionally, goats will be able to
24 access their shelters through the pasture, which is critical in the mitigation of daily stress during
25 the rainy season. Low stress handling and milking conditions can increase yields and will be
26 therefore important for GGD (Fuquay 1981, Collier et al. 1982, Rushen et al. 1999, Coleby
27 2012). Water and feed troughs will be designed to prevent goats from standing in, defecating in,
28 and contaminating drinking water. Water troughs will be rinsed daily and disinfected weekly.
29 During the dry season, feed troughs will be filled with groundnut hay for ad libitum feeding.
30 Pastures will include luceana and moringa trees for browsing and mental enrichment.

31 Lactating goats will be milked each morning and night. During this time, lactating goats

1 will be fed supplemental feed rations. Proper milking hygiene procedures will be put in place to
2 minimize mastitis in the herd and to ensure milk quality. Prior to milking, each goat will stand
3 on the stanchion and receive their daily ration. Each teat will be cleaned with an iodine spray
4 and an individual paper towel. Next, each teat will be stripped and milk quality will be
5 examined. Any questionable milk color or consistency should be tested with the California
6 Mastitis Test (CMT) to reduce the somatic cell count of the bulk tank milk. Normal halves will
7 be milked out fully, and the teat sprayed with iodine following milking. The milking parlor and
8 stanchions will be swept daily to remove all spilled feed and fecal material. The parlor will be
9 disinfected weekly.

10 Monthly preventative care is an important aspect of herd management. As such, each
11 month, all goats will have their hooves examined and trimmed to prevent lameness. CMT
12 testing should be performed on all lactating does monthly to limit mastitis in the herd. Each goat
13 should be inspected for their Faffa Malan Chart (FAMACHA) score and fecal examinations and
14 trypanosome smears should be performed on individuals considered at risk based on FAMACHA
15 score. Additionally, the bulk milk tank will be tested monthly for brucellosis to ensure the safety
16 of our product.

17

18 **Veterinary Care**

19 Preventative veterinary care is an integral aspect of proper herd management. GGD will
20 work closely with The Gambia Department of Livestock Services (DLS) to develop a
21 vaccination regimen for the herd. Each goat in the herd will be vaccinated for Peste des Petits
22 Ruminants (PPR) through DLS vaccination campaigns. Additionally, each goat will receive
23 Pasturella and Clostridium vaccinations funded internally by GGD. Goats will be dewormed
24 annually with Albendazole at the start of the rainy season.

25 GGD will work directly with the DLS Field Officer for the Bwiam area to ensure proper
26 health of the herd. Additionally, the herd manager will be trained as an auxiliary technician in
27 veterinary care, allowing them to perform vaccinations, deworming, castrations, and dehorning
28 (see staff responsibilities in Table 6). This staff member will be trained on and given protocols
29 for treatment and recognition of trypanosome infection, mastitis, dystocia, helminth infection,
30 and bloat. The herd manager will be trained to recognize significant signs of disease and should
31 contact DLS in emergency cases. To do so, the dairy will include a small laboratory with a

1 microscope, fecal examination supplies, PCV supplies and refractometer, and CMT testing
2 equipment.

3 Gambia Goat Dairy will have necessary medications to treat the aforementioned
4 conditions on hand. Trypanosome infection will be identified using PCV testing and buffy coat
5 examination under phase contrast or dark ground microscopy. When trypanosome infection is
6 identified in an animal, the goat will be treated with diminazine aceturate. Mastitis will be
7 identified using the CMT, which quantifies somatic cell count of the milk. Treatments for
8 clinical mastitis will include intramammary antibiotics, frequent milkings and massages of the
9 infected udder. Infected milk will be discarded as directed by a DLS veterinarian.

10 The herd manager will be trained on how to recognize and intervene in case of dystocia.
11 Crossing Saanen genetics to the WAD female will likely result in larger birth weight kids,
12 putting extra stress on the mother during kidding. Dystocia training will be critical to ensuring
13 the health of our herd.

14 Helminth infection will be diagnosed through multiple methods. FAMACHA scores,
15 indicating relative anemia of the goat, will be collected monthly, and used as an early warning of
16 potential parasitic infection. PCV samples will be collected and ran on goats suspected of
17 trypanosome infection, which will also indicate anemia and potential underlying helminth
18 infections. Importantly, fecal examinations will be performed on any goats suspected to have
19 nematode infections to diagnose the type of infection. Anthelmintic medications including
20 albendazole and sulfonamides for the treatment of nematode and coccidian infections,
21 respectively, will be kept on hand at the dairy.

22 Lastly, the herd manager will be trained to recognize signs of bloat resulting from
23 overeating concentrates or lush grasses. The rumen will be palpated to confirm bloat and bloat
24 remedy will be on hand at the dairy to administer as needed. Additionally, the technician will be
25 trained to manually eructate goats by elevating their forelimbs and pressing on the left flank, on
26 top of the rumen, to stimulate gas release. An orogastric tube will also be available should the
27 goat need more invasive manual release of gas.

28

29 **Farm Infrastructure**

30 *Buildings*

1 A large doe shed is needed to house 50 lactating goats (Figure 2). This structure should
2 measure 45x25m, with hay racks and water troughs on walls, sections for individual social
3 groups to congregate freely, and a passageway directly to their pasture (Coleby 2012). Raised
4 slatted floors will be installed to facilitate cleaning and deter termites, and adequate ventilation
5 must be installed.

6 This doe shed will be built around the existing ~12x8m structure that will be modified to
7 serve as a milking parlor (Figure 2). Lactating goats can therefore enter the milking parlor
8 directly from their shelter, consume concentrate feed while milking, and exit the opposite side of
9 the milking parlor into their pasture when finished.

10 A processing center with dimensions of ~12x8m will be constructed adjacent to the
11 milking parlor such that milk can be transported directly between buildings for immediate
12 processing (Figure 2). To prevent product contamination, the only passageway between the
13 milking parlor and processing center will be a small, sliding door that allows milk to be passed
14 between rooms. The processing center must have tile floors to facilitate proper cleaning.

15 A feed shed will be constructed adjacent to the doe shed with dimensions of roughly
16 12x8m (Figure 2). It will feature raised slatted floors to deter termites, and be located in an
17 accessible location to facilitate feed delivery.

18 A kid shed will be constructed near the opposite end of the property to prevent doe/kid
19 interaction (Figure 3). This shed will open up to a separate pasture to allow independent
20 browsing for older kids. The kid shed will be well ventilated with raised slatted floors to
21 facilitate cleaning and deter termites. Pens will be constructed within the kid shed to separate age
22 groups. Hay racks and water troughs will be installed.

23 At the far end of the pasture will be a separate enclosure including two parallel fences to
24 separate individual bucks from each other and from other goats, as a means of minimizing
25 aggressive contact between goats (Figure 1) (Coleby 2012). Five small shelters will be built
26 within this area for the 5 individual breeding studs. This structures will be small and may be
27 constructed with extra building materials from the other sheds. The stud shelters must be
28 optimized to provide adequate shelter from rain and prevailing winds while retaining ventilation
29 (Coleby 2012).

30
31 *Utilities*

1 Electricity must be installed in the milking parlor and processing center to allow for
2 cleaning and daily operations. Power will be supplied at no cost from the large solar field at
3 SJGH that will soon be constructed.

4 Plumbing must also be supplied to the milking parlor, processing center, and kid shed.
5 One spigot with a hose at the kid shed will be sufficient to supply the kids and bucks with
6 drinking water, and be sufficient for cleaning needs. A sink should be installed in the milking
7 parlor to clean milking equipment, and a spigot should also be installed for cleaning purposes. A
8 hose run from this second spigot to the doe shed should be sufficient to clean the doe shed and
9 provide does with drinking water. The processing center should also have a sink for equipment
10 cleaning, and a spigot that can be used to clean floors and larger equipment.

11 12 *Equipment*

13 Capital expenditures for equipment are listed in the GGD 3 Year Cash Flow Budget
14 (Figure 5). Major equipment expense categories include milking, milk processing, farm
15 equipment, breeding, veterinary, and replacement parts. These costs are separated by fiscal year.

16 17 **Dairy Processing**

18 *Milk Collection*

19 Hand milking is the most profitable means of milking goats with herds of less than 70
20 (Coleby 2012). Future options to scale up the enterprise can include automatic milkers if the herd
21 exceeds this size. Before milking, iodine will be applied to each udder with a spray bottle and
22 individual paper towel to clean teats and to reduce milk contamination. Strip milk cups will then
23 be used to assess the general quality of milk before milking. Milk will then be collected in
24 stainless steel milking pails then transferred directly to the processing center.

25 26 *Pasteurization*

27 Once collected, milk pails will be transferred to the processing center through a small
28 sliding door between rooms. Milk sachets will be gravity fed by the Milk-Pro system, sealed,
29 then placed in a batch pasteurizer. The milk is automatically heated to 65°C for 30 minutes.
30 Sachets are then cooled to 5°C by a chilling unit (FAO 1988).

31

1 *Yogurt*

2 Milk will also be processed as yogurt. Culture will be prepared and added to milk as
3 specified by the village milk processing procedure of the FAO (Figure 4). Yogurt cartons will be
4 filled and sealed by a hand-sealer, then stored in a refrigerator until sale.

6 **Biosecurity**

7 Biosecurity is a priority of GGD, and is vital in maximizing herd health and preventing
8 product contamination. It will be important to limit herd movement by fences and prevent other
9 animals from entering the GGD pasture, as a means of avoiding disease transmission from
10 outside the farm. Similarly, unhealthy animals must be isolated for treatment in order to prevent
11 disease spread within the herd.

12 One specific zoonotic disease that must be addressed is Q fever, caused by the gram
13 negative bacteria *Coxiella burnetii*. *C. burnetii* has with a major reservoir of small ruminants for
14 infection of humans (Klaasen et al. 2014). It can be spread to humans via the milk, urine, and
15 feces of infected animals, often through inhalation of barnyard dust (Hoek et al. 2013). There is a
16 substantial seroprevalance of *C. burnetii* in The Gambia, and it is considered a possible cause of
17 acute febrile illness (Klaasen et al. 2014). This illustrates the incredible importance of
18 biosecurity measures that limit livestock-human exposure with such close proximity to SJGH,
19 where the most vulnerable individuals are located (pregnant women and immunosuppressed
20 patients) (Maurin and Raoult 1999). The biosecurity measures outlined below will be important
21 in limiting such zoonotic transmission of this disease.

22 Specifically, animals will be regularly tested with Q fever ELISA kits to ensure a low
23 microbial load at GGD, and affected goats must be treated immediately with doxycycline to
24 reduce the risk of transmission to humans (Klaasen et al. 2014). The processing center must be
25 isolated from the surrounding farm. Passing milk pails through a small door to the processing
26 center rather than transporting them by foot will reduce the prevalence of contaminants in the
27 center. Similarly, shoes must be changed or disinfected before entering the processing center.
28 Head coverings, masks, lab coats, and gloves should also be employed when processing milk.
29 These practices will be important in maintaining the high quality of GGD dairy products.
30 Additionally, the bulk tank milk will be tested for brucellosis and somatic cell counts regularly to

1 ensure the quality and safety of the milk. Lastly, employees must maintain a health record free
2 of Tuberculosis and other transmissible diseases.

3 The Milk-Pro system, which pasteurizes milk in the same sealed package that is sold, will
4 be used as it is vital in mitigating post-processing contamination. (FAO 1988). As raw milk
5 consumed in The Gambia is highly contaminated and poses a significant risk to public health, the
6 Milk-Pro system offers a small scale, sustainable option to combat this issue (Hempen et al.
7 2004).

8

9 **Labor**

10 GGD will hire staff from the Bwiam community to carry out everyday operations.
11 Women with an appropriate skillset will be specifically encouraged to apply for GGD positions
12 as a means of empowering women and improving their economic position.

13 The herd manager will be the most important employee, with the widest range of
14 responsibilities. The herd manager will be responsible for feeding goats and providing daily
15 veterinary care as an auxiliary technician trained by the DLS. The herd manager should have a
16 driver's license and be responsible for the purchase and transport of goat feed and farm
17 equipment. This employee's responsibilities will also include finance, payroll, and budgeting for
18 GGD.

19 Two milk processing employees will also be hired by GGD, with primary responsibilities
20 of milking, pasteurization, processing, and packaging. These employees will also be expected to
21 assist the herd manager whenever he or she is unable to perform all daily roles.

22 A Bwiam market vendor must be hired to transport dairy products to the point of sale.
23 This employee will also be expected to direct advertising and marketing efforts and sell GGD
24 products.

25 GGD will hire a staff member who can maintain farm infrastructure. This person will be
26 responsible for all building and equipment repairs, including the maintenance of dairy
27 processing.

28 It will also be necessary for security personnel to prevent the theft of animals and
29 equipment, especially at night. As an enterprise operating within the walls of SJGH, GGD will
30 subsidize the extra responsibilities of preexisting SJGH security to achieve this end.

31

1 **Community Assets to be Leveraged**

2 By establishing GGD in association with SJGH and in the community of Bwiam, we will
3 access many benefits specific to the area. Namely, the hospital will help provide electricity,
4 water, land, and name recognition, while Bwiam will offer a daily market.

5 GGD will need to have access to ample electricity in order to fulfill the needs for
6 sanitation, processing, pasteurization and refrigeration of dairy products. Currently, electricity
7 tariffs are high in The Gambia and the electricity supply is often erratic in nature, forcing small
8 businesses to maintain backup generators and incur high energy costs. In 2009, SJGH partnered
9 with Power Up Gambia (PUG) to develop a solar (photovoltaic) energy field for powering
10 hospital operations. The hospital hopes to expand this solar field in 2016-2017 in order to have
11 sufficient power to run GGD as well. An expanded solar energy field could provide 20+ years of
12 clean, free and reliable electricity to GGD, significantly improving its long term economic
13 sustainability (PUG 2016).

14 Additionally, the hospital bore hole will provide sufficient, safe water for the needs of the
15 dairy, which is vital for ensuring desired milk production levels. SJGH will also provide 1.8
16 hectares of land to GGD, allowing for sheds to house milking does, kids and bucks, as well as a
17 milking parlor, milk-processing room, and feed shed (Figure 1). This land is within the hospital
18 compound, providing the dairy with limited security from the hospital walls. Lastly, by
19 establishing GGD with SJGH, we attain positive name recognition and a sense of acceptance
20 from consumers whom trust the hospital in promoting overall health. This is particularly
21 important to GGD as we begin to introduce unfamiliar products to the community.
22 Consequently, with SJGH promoting and supporting our products, consumers will presumably
23 find our educational campaigns on the benefits of goat milk and pasteurization more trustworthy.
24 This acceptance will not only allow GGD to sell more dairy, but will connect the community
25 with safer, healthier milk products.

26 The community of Bwiam is an ideal location for the establishment of GGD due to its
27 daily market and its proximity to the Kombos. The market in Bwiam allows the dairy an
28 accessible daily market to sell our products. Daily sales are necessary in GGD's self-sufficiency,
29 and will be the primary source of revenue for medication subsidies for the malnutrition ward of
30 SJGH. The market will also allow us to reach a large proportion and demographic of individuals
31 in Bwiam. This is important in providing local, safe protein sources to families in need. There is

1 a strong structure of leadership within the community of Bwiam, specifically through local
2 Imams and local communicators, which can be leveraged to rally support for GGD and involve
3 community members to establish a sense of ownership of GGD in Bwiam. Lastly, Bwiam is
4 located on the main highway with 1.5 hours of travel necessary to reach the Kombos region.
5 This will help GGD easily access resources located in the Kombos, such as the livestock and
6 feed markets.

7

8 **GENERATING REVENUE**

9 Adequate revenue must be generated internally for The Gambia Goat Dairy to achieve
10 long term viability, and the ability to do so is contingent upon dairy, manure, and goat sales.
11 Furthermore, the dairy must be able to market products at sufficiently low prices to outcompete
12 highly prevalent imported brands. This is important in reaching vulnerable populations who
13 stand to benefit most from increasing their daily protein intake, and in supporting the Gambian
14 economy by reducing import reliance.

15

16 **Demand**

17 To assess local demand for dairy and illuminate the existence of any cultural barriers to
18 the sale of goat milk, an informal survey of the Bwiam market was conducted by GGD's project
19 managers in July 2016 (Table 2, 3). The survey also evaluated the malleability of consumer
20 attitudes when presented with new information concerning a product. Respondents were
21 approached in person in the market over the course of one day and asked questions assessing
22 their attitudes towards various dairy products. Questions were displayed on a laptop screen, on
23 which respondents could point to or voice their desired answer. Questions were mostly binary,
24 with three numerical response and six open ended inquiries. A translator was present for
25 respondents who were unable to interact in English.

26 All respondents had drunk milk before, and most had also eaten yogurt (Table 2).
27 Responses were largely positive concerning the purchase of affordable goat dairy. Concerning
28 goat milk, respondents were slightly less receptive to the prospect of paying the same price as
29 imported brands of cow milk (reasons given included high price point and lack of product
30 familiarity). However, respondents were more receptive to the prospect of paying the same price

1 as imported brands of cow yogurt. Half of all respondents interviewed were aware that goat milk
2 could be healthier than cow milk.

3 Half of all respondents interviewed would buy goat milk every day if available and
4 affordable, while slightly fewer would buy yogurt every day (Table 3). Of the remaining
5 respondents, most would buy milk or yogurt one or more times a week, and a minority would
6 buy it less often or not at all. Interestingly, when informed in a few sentences about the potential
7 health benefits of goat milk over cow milk, a majority of respondents said they would increase
8 their purchase frequency. Of these respondents, some increased their frequency to multiple times
9 per day, while others shifted from once or twice a week to daily purchases.

10 While limited by sample size and largely informal, this survey rejects the notion of
11 widespread cultural opposition to the consumption of goat milk within the Bwiam community. It
12 shows that demand for dairy exists at some level in Bwiam, and suggests that the attitudes of
13 consumers may be malleable by outreach campaigns that educate individuals about the value of
14 goat milk. This trait can be leveraged by proper marketing of goat dairy products to achieve
15 necessary sales.

16 Further research conducted similarly on a larger sample size would help to quantify
17 demand and identify local demographics to be targeted by specific sales strategies. One option
18 for expanding the survey in the future involves the DLS and The Gambia Bureau of Statistics; in
19 partnering with these institutions, GGD can add survey questions to the upcoming census and
20 generate results from much larger sample size.

21

22 **Marketing**

23 The Bwiam market survey indicated that consumer attitudes could be affected relatively
24 easily by a simple, health-related message. Thus, outreach campaigns and marketing techniques
25 should focus on similar messages delivered via diverse media to reach all local demographics
26 within and outside the Bwiam community. Dairy quality and food safety, health benefits, price
27 point, name recognition (as a business owned by SJGH), taste and packaging, and demonstration
28 of the model's profitability to entice local farmers to follow suit are major points of
29 advertisement that must be addressed.

30 Some preliminary advertising options have been investigated in Bwiam. The Bwiam
31 Radio Station is widely known within Bwiam and in neighboring communities, and has agreed to

1 advertise GGD products, at prices that will be negotiated according to airtime and frequency.
2 Printed advertisements have traditionally failed as methods of product marketing in Bwiam, and
3 will therefore not be employed by GGD. Dairy samples will be provided free of charge
4 preceding GGD product sales, to promote product familiarity and as a means of product testing
5 for taste and consumer preference. School children will be important targets of advertising
6 efforts and sample distribution, as they often drive their parents' purchases. Visiting days at
7 GGD are another means of reaching potential customers, as individuals with a deeper connection
8 with and understanding of the farm and milking process will be more familiar with and receptive
9 to the product.

10 Goat, manure, and hide sales are other significant source of revenue for GGD. The
11 Gambia Livestock Marketing Agency (GLMA) has agreed to assist in marketing our animals and
12 their by-products. GGD goats will be sold at a higher price point than most animals due to their
13 increased weight. As they cost more than average goats to raise, this price point will be necessary
14 to enforce in order to ensure adequate returns.

15 The option of selling dairy to large scale producers and/or distributors must be evaluated
16 in terms of profitability and financial sustainability. It will be important to involve the private
17 sector because the relative lack of leadership turnover in private institutions compared to
18 government institutions decreases risk and should maximize GGD's financial stability (ITC
19 2016). It will therefore be important to quickly identify businesses interested in GGD as a long
20 term commercial partner. Furthermore, these opportunities must be examined to ensure that
21 target populations in need of affordable protein are still being prioritized.

22

23 **Pricing**

24 GGD dairy prices should be formulated to ensure financial viability of the operation
25 without compromising the goal of providing affordable, high quality protein to vulnerable
26 populations. One method of achieving this is to sell milk at the lowest existing market price and
27 provide free milk sachets to the neediest families while selling yogurt at a higher price,
28 effectively subsidizing milk production with the sale of yogurt, goats, manure, and hides. This
29 ensures the availability of affordable protein, but is contingent upon adequate demand for GGD's
30 other products. Actual price points must be carefully adjusted in response to demand and
31 operating costs as GGD begins operating self-sufficiently. Furthermore, the neediest populations

1 must be accurately identified if they are to be reached by GGD. One way of achieving this is to
2 allow SJGH nurses and doctors to “prescribe” a certain amount of GGD dairy to the neediest
3 individuals as identified by the hospital, who will then be eligible to receive products for free.
4

5 **Sales Estimates**

6 No data exists on commercial goat milk sales in The Gambia. A study of cow milk sales
7 was conducted in 2002 and reported average monthly sales of roughly 360 kg of dairy (Somda et
8 al. 2003). However, the ITC reported that this figure represents a minority of actual dairy sales,
9 as most transactions take place informally between farmers and consumers in local markets.
10 More research that seeks to quantify potential goat dairy sales will be necessary to confirm
11 revenue estimates as GGD begins producing milk on a commercial scale.
12

13 **Financial Viability – Long Term Analysis**

14 The long term viability of GGD is contingent upon its ability to sustain operations solely
15 via internal revenue. To assess the plausibility of this outcome, operating costs and avenues of
16 revenue were modeled and a daily profit margin was calculated (Figure 6).

17 A number of underlying assumptions are inherent in the model. First, the profit margin is
18 dependent upon the ability to sell all milk produced at the price listed. The model does not
19 account for variance in yield between goats, and estimates the average number of lactating
20 females given a strict, 8-month kidding cycle. Half of all milk produced is assumed to be
21 converted into an equal volume of yogurt. All F2 kids are assumed to be sold at exactly 6 months
22 of age.

23 Given these assumptions, the model points to a viable commercial operation given the
24 expenses listed. Looking forward, it will be important to adjust all parameters and price points to
25 accurately reflect day to day operations and identify areas in need of optimization. An example
26 of a specific issue to be examined with this model is the financial benefit of growing feed versus
27 purchasing feed. While it will likely be cheaper to grow feed and ensure high feed quality, this
28 advantage must be carefully weighed against the environmental cost of increased land use,
29 wasted crop use, and bush fires. The model will also be useful in exploring ventures such as
30 cheese making and alternative sales options. It will also be vital to achieve a greater
31 understanding of the physiology of the hybrid goats to be able to optimize ration formulations

1 and employ linear programming as a means of maximizing the health, productive capacity, and
2 profitability of each animal while minimizing environmental impact.

4 **SUSTAINABILITY**

5 To ensure the long-term success of Gambia Goat Dairy, efforts to ensure sustainability
6 are of critical importance. GGD aims to exist as a financially self-sufficient dairy operated solely
7 by Gambians without reliance on international input. By creating detailed plans and budgets and
8 connecting important stakeholding groups and organizations, GGD staff and SJGH will quickly
9 gain control of the project and ensure its long-term success. To achieve this end, GGD will
10 employ local advising services and training for staff, including workshops and teaching
11 certification programs on husbandry, nutrition, hygiene, and breeding. Additionally, local
12 veterinary care both for the GGD herd and for the greater community will encourage the
13 importance of preventative medicine and veterinary care.

14 The initial phase of this project involves training for staff members to guarantee the
15 success and safety of the dairy. When GGD becomes productive and profitable, the following
16 phase can be implemented to focus on greater community outreach. Workshops will be
17 replicated on a larger scale for other smallholder farmers to attend. In this phase, we hope to
18 increase the productivity of animals in the community and demonstrate the financial benefits of
19 GGD's husbandry model, thereby increasing local milk production to meet the protein needs of
20 families in the area. When complete, we hope to replicate GGD's model in other communities
21 interested in increasing their local milk production.

23 **Local Advising Services and Training for Staff**

24 Advising and training services will cover five main topics: husbandry, nutrition, hygiene,
25 breeding, and business. Local and international experts will lead these workshops to ensure that
26 the most qualified teacher is involved in each area (see Table 1 for a list of organizations that
27 have pledged their support of this effort). Training for staff will include teaching certification so
28 that the staff member can lead workshops in the future for farmers of the community.

30 *Husbandry Training*

31 Each staff member working directly with goats will receive husbandry training. These

1 trainees include the herd manager and milking staff. The training sessions will cover the
2 husbandry protocol outlined previously as well as the incorporation of low-stress handling
3 techniques and issues of animal welfare. Staff receiving the training will also learn how to train
4 other farmers to ensure the long-term continuity of GGD workshops educating smallholder
5 farmers in proper husbandry techniques. Through low-stress handling and principles of goat care
6 taught through these workshops, farmers will learn how to create safe, healthy environments for
7 their goats to decrease disease susceptibility and increase productivity.

8

9 *Nutrition Training*

10 Proper nutrition of the goats at the dairy will ensure stable and high levels of milk
11 production. Mr. Matarr Njai, a retired DLS livestock feeds researcher, will teach proper goat
12 nutrition to the herd manager and any other staff members responsible for daily feeding of goats
13 or feed storage. The training will cover the previously outlined nutrition protocols, specifically
14 highlighting the following areas: amounts of hay, supplement, and pasture for each physiologic
15 group of goats; proper preparation and storage of feeds; mineral block preparation and the
16 importance of minerals in goat diets. This training will also involve a teaching certification, such
17 that the staff trained will be capable of holding workshops for the greater community on goat
18 nutrition. The spread of such information to local farmers who can in turn teach the importance
19 of balanced nutrition, especially in the dry season, will ultimately improve animal productivity.

20

21 *Hygiene Training*

22 Hygiene is critical to limiting the spread of disease in a commercial dairy setting.
23 Because of this, any staff member working directly with the goats, such as the herd manager,
24 milking staff and milk processing staff will receive hygiene training. Two different training
25 sessions will be tailored to the staffs' role in the dairy. One session, targeting the herd manager
26 and milking staff, will cover the milking protocol and disinfection protocol described previously.
27 The milking protocol includes the iodine cleaning of each teat, stripping and examination of
28 milk, and iodine spray following milking performed on each lactating goat during milking. The
29 disinfection protocol covers daily sweeping and weekly disinfection of all animal areas, and the
30 cleaning of feed and water troughs. Another session, targeting the milk processing staff, will
31 cover use, maintenance, and repair of the pasteurization equipment. The training will also focus

1 on cleanliness and safe handling techniques to limit post-processing contamination, especially in
2 the production of other milk products.

3

4 *Breeding Training*

5 GGD will either follow the aforementioned straight breeding strategy, or the breeding
6 protocol outlined by Dhollander and her colleagues in 2004, as previously described. Staff will
7 be educated on the importance of preventing endemic genetic dilution if the latter is employed.
8 The herd manager will be responsible for breeding procedures, including detailed record
9 keeping. Adequate training in AI and dystocia management are critical in any controlled cross-
10 breeding regimen. Later phases of the project include the loaning of F1 females to local farmers
11 who receive training on the importance of crossbreeding or selective straight breeding and
12 maintaining endemic genetics. GGD may then purchase dairy from these farmers for processing
13 and sale (as outlined in “Future Directions”). GGD staff will lead these workshops and farmers
14 will be carefully selected based on their interest, knowledge, and willingness to work with our
15 staff.

16

17 *Business Training*

18 When successful, the business model of GGD will be important for farmers to understand
19 if they are to benefit from the same strategy. Without an understanding of the financial models
20 that allow for GGD’s success, farmers will lack incentive to adopt the model and be unable to
21 similarly generate wealth. GGD’s herd manager must therefore have a comprehensive
22 understanding of GGD’s finances, to the point where he or she can educate others on the
23 underlying processes and measures taken to ensure success. It will then be vital in GGD
24 workshops for the herd manager and other project leaders to impart this knowledge to attendees
25 if they too are to realize success.

26

27 *Key Players*

28 Key individuals to be involved in GGD training sessions include Corey Spies and
29 Brianna Parsons (veterinary students and project managers), Saja Kora (goat crossbreeding
30 expert), Matarr Njai (retired DLS feeds researcher), and various representatives from DLS, ITC,
31 and the National Agricultural Research Institute (NARI).

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Local Veterinary Care

GGD will need effective veterinary care in order for our herd to live long, productive lives. This is of critical importance when introducing foreign genetics to The Gambia with the expectation of high milk production. Because of the need for continual herd care, GGD will work directly with the DLS Field Officer for the Bwiam region. As previously described, the herd will have a strict vaccination and deworming regimen to help prevent transmission of disease within the herd. A trained auxiliary technician on staff will be able to treat minor health problems and will identify when a veterinarian's services are needed. The DLS Field Officer will be available for emergency services.

GGD will hold workshops for the community on the importance of vaccination for preventative and herd health. With the help of the DLS, GGD will host vaccination clinics for farmers in the area. As later phases involve the expansion of GGD into a center for animal health, farmers in the community will eventually come and consult with the GGD herd manager and DLS Field Officer about health issues in their herds.

Environmental Sustainability

GGD is responsible for maintaining health of the ecosystem in which it operates. To do so, building materials must be carefully chosen and sustainably sourced. Landscape alteration should be minimized, and replanting of fodder trees and endemic grasses should be prioritized. As a semi-intensive operation, GGD must remain conscious of the nitrogen load it imposes on its farmland ecosystem, and should seek to mitigate deposition with proper ration formulation, composting, and manure sales. GGD should serve as a model for sustainable, small scale, semi-intensive agriculture and promote the widespread adoption of similarly environmentally conscious initiatives in order to minimize the ecological impact of livestock.

FUTURE DIRECTIONS

As the project accomplishes the initial goal of becoming a financially self-sufficient dairy farm operated by Gambians without reliance on international input, ideas for expansion can be considered. Many of the critical early phase workshops outlined previously can be expanded to reach farmers of the greater Bwiam community. Namely, GGD aims to host smallholder training

1 workshops, a F1 lending program, a local dairy processing cooperative, and an animal health
2 center through efforts to scale up.

3 First, GGD workshops will teach smallholder farmers husbandry, hygiene, business, and
4 nutrition management practices that have proven successful at GGD to give farmers ownership
5 over the productivity of and wealth created by their own herds. Throughout this process, it will
6 be important to communicate well with community leaders and smallholder farmers in order to
7 identify those individuals who will use the information most appropriately and successfully.
8 Second, GGD will loan F1 females to trained farmers to promote local milk production and
9 wealth generation. The F1 females will be loaned, instead of given, to local farmers to emphasize
10 the importance of the animals. Each farmer will undergo extensive training in management
11 techniques and the loaned animals will be evaluated monthly by our staff to ensure they are
12 being cared for in our approved system. The milk produced will be sold back to GGD through
13 our local cooperative. This system provides farmers with a market for the milk produced,
14 thereby improving their individual economic livelihood and expanding the local milk sector.
15 Other independent farmers in the area may also sell milk to our pasteurizing cooperative, to
16 ensure fair milk prices for farmers and a safer product for consumers. One way to incentivize
17 farmers to adopt this system is to replicate a model used previously by the ITC in Bansang. In
18 this case, F1s were given to farmers for a short period of time, and the farmers were allowed to
19 keep any F2 animals that were born as long as they adhered to the management practices set
20 forth by the ITC. Similarly, GGD may incentivize the lending program by promising F2 kids to
21 participating farmers.

22 Lastly, GGD can become a center for animal health, by expanding our staff to include
23 additional trained technicians and staff veterinarians. GGD's healthcare center will work directly
24 with the dairy itself to target farmers attending our workshops. The center will emphasize the
25 importance of animal healthcare to improve productivity, in order to teach and encourage
26 optimal animal welfare within farms in The Gambia.

27 Through the success of these initiatives, GGD will become a model institution for other
28 communities throughout The Gambia aspiring to start a dairy. Due to the lacking domestic dairy
29 sector, GGD can show local farmers that dairy is a lucrative market. To this end, GGD should
30 offer advising services and financial guidance to any interested smallholders in an effort to
31 spread the GGD model and address the widespread challenges of Gambian communities.

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POTENTIAL CHALLENGES

Securing Start-Up Funding

One major challenge is securing adequate start-up funding. Without sufficient funding, GGD will lack the quality of infrastructure necessary to start a profitable dairy. To address this challenge, GGD will seek funding from a variety of different organizations. This proposal will be distributed with letters of support from Gambian stakeholders, indicating that the proposal is comprehensive and supported by the community in which GGD will operate. Additionally, outreach initiatives including lectures and discussion with students and faculty of the University of Pennsylvania, Drexel University, and other global health and international development events will be conducted to gain international support for the initiative. Any potential media outlets will also be utilized in both the U.S. and Gambia.

Overcoming Cultural Barriers to Commercial Goat Milk

GGD will incur two major challenges in terms of marketing goat milk and milk products in The Gambia. First, goat milk is rarely (if ever) drank by most Gambians due to the low productivity of endemic goats (Marshall et al. 2011). Second, the small size and lack of formality in the Gambian local dairy sector renders the GGD an objectively risky venture, as evidence-based business strategies cannot be secured (MacMillan and Thompson 2013).

The Bwiam market survey results indicate that individuals are willing to try, and eventually buy, goat milk and products if they find them of good quality and an affordable price (Table 2,3). While this bodes well for the sale of goat milk, it will be important to ensure that product development, marketing, and sales strategies can be tailored to and adapt to the culture in which they operate. The plans and goals of GGD will be advertised through local radio stations, so that consumers understand both the benefits of goat milk products and their accessibility. GGD products will initially be available as free samples to sensitize and educate consumers. These samples will be distributed at farm visits, in the Bwiam market, at SJGH, in schools, and to community leaders such as Imams. Opportunities to sell milk to commercial enterprises should be explored as well, as these points of sale may be more stable and profitable.

Furthermore, village and community health workers who are already involved with the Bwiam community should be made aware of GGD's goal. Collaboration should be established to

1 help determine the most vulnerable populations and how best to reach them.

2

3 **Disease in Hybrids**

4 A serious concern for GGD is the health status of hybrid goats in a cross-breeding
5 scenario. Though crossbred goats can dramatically increase milk yields, they have the potential
6 to succumb to diseases due to unexposed Saanen genetics (Dhollander et al. 2005). While
7 Dhollander et al. showed that F1 crossbreds experienced similar disease rates as the WAD in
8 terms of helminth, coccidian and trypanosome infections, it is still important to consider their
9 potential for increased disease incidences in a new environment. To minimize disease risk,
10 regular surveillance protocols will be implemented and supported with adequate laboratory
11 testing equipment on site, and proper herd health practices will be enforced. GGD's herd
12 manager will be properly trained as an auxiliary technician, and GGD will have an intimate
13 working relationship with the DLS.

14

15 **Maintenance of Adequate Production Levels**

16 GGD must produce and market milk on a profitable level. Without income from product
17 sales, GGD will fail to achieve self-sufficiency and will subsequently fail. To ensure
18 profitability before undertaking the project, daily profits were modeled and projected (Figure 6).
19 Sales estimates are supported by the Bwiam market survey, but should be quantified by further
20 market research (Table 2, 3). Given these estimates, GGD will quickly achieve a financially
21 sustainable status with adequate start-up funding.

22 The increased yield of F1 females should easily meet and exceed the level of supply
23 necessary to generate profit. Disease outbreak and subsequent herd size reduction could
24 temporarily affect yields, but the AI abilities of the GGD staff should ensure the replacement of
25 any lost F1 animals. Thus, the AI capacity of the dairy will allow replacement goats to be bred as
26 needed as female F1s decrease in productive capacity.

27

28 **Excessive Maintenance Costs or the Inability to Conduct Repairs**

29 The inability to afford upkeep and repairs of the equipment and facilities of the dairy will
30 result in its ultimate failure. Estimations of daily and yearly profit and loss include maintenance
31 costs for all equipment and buildings and equipment (Figure 5,6). These costs were estimated at

1 higher values than are likely in an attempt to account for unforeseen issues.

2

3 **Backlash from Farmers Losing Business**

4 The provision of high quality dairy at the same price point as the cheapest dairy products
5 will likely disrupt the abilities of other local farmers to sell dairy. To limit farmer losses, GGD
6 will implement a processing cooperative and incentivize smallholder involvement as soon as
7 possible. This will allow farmers to sell raw milk to GGD for a fair price for processing,
8 effectively supporting the livelihood of local farmers while improving the quality of milk
9 available to the community. While cooperative models can endow farmers with greater control
10 over sales prices, careful planning and understanding of smallholder attitudes will be necessary
11 to ensure success.

12 Furthermore, farmers must be able to see the benefits of GGD's model for their own
13 business. It will therefore be important to communicate with smallholders and community
14 leaders early on to identify promising individuals who can adopt GGD's techniques to his or her
15 own farm and quickly benefit. To achieve this, smallholder farm visits, lending programs, and
16 training workshops are of utmost importance.

17

18 **Access to Credit, Micro-Lending Issues, and Smallholder Involvement**

19 A goal of GGD is to help all farmers improve livestock productivity, regardless of animal
20 species or use, as a means of generating wealth. Part of this plan involves loaning productive F1
21 females to farmers for a small price to emphasize the animals' value. If farmers cannot pay this
22 given their current savings and must apply for funding, the current micro-lending organizations
23 may charge farmers exorbitant interest rates. This will prohibit farmers from accessing and
24 benefitting from vital GGD outreach initiatives targeted at improving local agriculture. To
25 address this, further research into the nature of local lending organizations must be conducted
26 and optimal lending options must be secured. Alternatively, GGD can investigate options such
27 as allowing smallholders to pay for hybrids with the dairy they produce.

28

29 **Difficulty in Model Replication**

30 Some Gambian stakeholders raised concerns about the ability of GGD to expand and
31 replicate its model dairy operation elsewhere in The Gambia. After group discussions, a few

1 points were illuminated that address this issue. First, The Gambia's geography is relatively
2 homogenous compared to larger African countries, with some variation between coastal and
3 inland regions and riverside and outlying regions (Marshall et al. 2011). This facilitates model
4 replication in that the soil, vegetation, farmland biodiversity, rainfall and water availability, and
5 crop availability in future dairy sites will be relatively similar. Next, a suggestion was put for to
6 work with The Gambia Department of Community Development. This sector will be helpful in
7 targeting community leaders to be involved in education and outreach such that the community
8 fosters involvement, ownership, and support of the operation and supports it proudly as a
9 Gambian initiative. This will facilitate the replication of GGD's model as other communities are
10 more likely to adopt a system that is genuinely supported and ultimately owned by by their
11 friends and neighbors.

12

13 **Environmental Concerns**

14 There are a few specific environmental concerns that must be addressed when
15 implementing a semi-intensive livestock system. First, intensive agricultural systems impose a
16 greater nitrogen load on soil than do extensive systems (Brouwer et al. 1999, Kato et al. 2009).
17 This excess nitrogen directly results in the pollution of waterways through harmful algal blooms
18 due to farm runoff (Vitousek et al. 1997, Carpenter et al. 1998, Cahoon et al. 1999, Karr et al.
19 2001). It will therefore be very important to carefully formulate rations in a way that minimizes
20 the nitrogen content of animal waste. Linear programming can be employed with an
21 understanding of WAD or hybrid physiology as a means of achieving this end. Furthermore,
22 nitrogen can be diverted from soil through composting procedures and through the sale of
23 manure to local farmers as natural fertilizer.

24 Intensive agricultural operations have significantly less farmland biodiversity across
25 numerous taxa, with negative implications for environmental and livestock health (Benton et al.
26 2003, Kleijn et al. 2009). To combat this, GGD will employ a semi-intensive production system.
27 This utilizes concentrate feed as well as grazing practices in a smaller pasture as a means of
28 achieving ecological heterogeneity on the farm without compromising productivity per unit land.
29 Retaining pasture health will be vital in promoting the health of our livestock as well as the
30 environment we depend upon.

1 It will also be important to ensure the sustainable sourcing of building materials, farm
2 equipment, and product packaging. Infrastructure must be constructed with consideration for the
3 ecological impact posed by the materials consumed, and this impact must be carefully weighed
4 against the benefits offered by the operation. Specifically, the use of African mahogany (a
5 common building material in The Gambia and major victim of deforestation) should be
6 minimized and alternative materials should be sourced (DPWM 2014). Additionally, options for
7 biodegradable product packaging must be explored and every effort must be made to mitigate the
8 waste produced by GGD.

9

10 **EVALUATING SUCCESS**

11 As a means of ensuring accountability, measures of success must be established and
12 evaluated. Three areas that must be evaluated to measure success are community nutrition,
13 hospital subsidization, and business expansion (Table 3).

14 With the principal goal of mitigating malnourishment in The Gambia, the amount of high
15 quality protein made accessible to vulnerable populations will be the primary measure of GGD's
16 success. The unit of measurement will be liters of GGD dairy distributed daily to vulnerable
17 populations in Bwiam, either for free or at a low, subsidized price. If sold, the price must remain
18 below the lowest price point of milk for sale in the Bwiam market (raw cow milk informally sold
19 by local farmers), which is currently inaccessible for some families (personal correspondence
20 with community member). Further research must be done to understand the percentage of the
21 population to which milk is currently inaccessible in order to establish a baseline level. This unit
22 of measurement should indicate actual consumption of high quality protein by needy families if
23 sales are supported by educational outreach and marketing to these populations. Given our
24 current models of productivity and finance and the necessity to sell some portion of produced
25 dairy at a higher price point to subsidize affordable milk, a plausible goal is to provide 40 liters
26 of affordable milk every day at the Bwiam market by the year 2020. Given an average protein
27 requirement of 3 oz per day for children between 2 and 8, this represents the fulfillment of
28 6321.8 daily protein requirements for vulnerable children per year (USDA nutrient database on
29 milkfacts.info, USDA choosemyplate.gov).

30 GGD also aims to subsidize SJGH to enable the purchase of inaccessible medications.
31 Success in this area will be measured by the number of medications purchased that were

1 previously absent due to cost. Additional data must be collected to establish a baseline level for
2 medication access and to set a plausible goal for improvement.

3 While difficult to quantify, the final means of evaluating success involves different
4 markers indicating the ability of GGD to sustain itself and achieve greater goals without
5 international input. Establishing a successful processing cooperative and F1 lending program
6 amongst smallholder farms are two such markers. Progressing beyond the maintenance of daily
7 operations to a point at which internally generated revenue can be invested in scaling up or
8 replicating the model elsewhere is an additional marker as it indicates the promotion of food
9 security in the Gambia and reduction of import reliance.

10 **ACKNOWLEDGEMENTS**

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TABLES AND FIGURES

Table 1. Stakeholder groups and organizations involved

Stakeholding Group	Representatives	Phone	Email
University of Pennsylvania School of Veterinary Medicine (PennVet)	Brianna Parsons BA	1-215-206-8538	parsonsbrianna@gmail.com
	Corey Spies BSc	1-973-216-9711 220-213-6178	cspies@vet.upenn.edu
	David Galligan BA, VMD, MBA		galligan@vet.upenn.edu
National Nutrition Agency (NaNA)	Mr. Modou Phall – Executive Director <i>Additional Representatives</i>	220-995-4038	modouchevassinphall@yahoo.com
Sulayman Junkung General Hospital (SJGH)	Mr. Kebba Badgie – CEO Mr. Ousmain Jallow – Director of Human Resources	220-362-3434 220-387-6056	fankerod@gmail.com ousmanyfjallow@yahoo.com
Department of Livestock Services (DLS)	Dr. Duto Sainy Fofana – Director General Dr. Ousmain Ceesay – Chief Veterinary Officer Mr. Bakary Jammeh – WCR Regional Director Mr. Matarr Njai – Livestock Feeds Researcher	220-764-5679 220-764-5679 220-975-3182	dsfofana1@gmail.com
Gambia Livestock Marketing Agency (GLMA)	Mr. Bakary Badgie – Director General Mr. Ebrima Cham – Operations Manager Mr. Abdoulie Manjang (GLMA Abuko)	220-996-7391	
International Trypanotolerance Center (ITC)	Dr. Arss Secka – Researcher Mr. Saja Kora – Goat Crossbreeding Expert Dr. Olawale Olaniyan – Researcher Mr. Mommodou Jeng Mr. Ansumana Ceesay Mr. Lamin Drammeh	220-394-5904 220-777-0404 220-370-1318	seckaars@gmail.com korasaja@yahoo.com ofolaniyan@hotmail.com mojeng2000@hotmail.com
Private Farmer	Mr. Joseph Faye	220-772-2548	fayelatyr@gmail.com
Power Up Gambia (PUG)	Lynn McConville – Executive Director	1-267-456-3753	lmconville@powerupgambia.org
Rotary	Carla Chieffo VMD, PhD	1-610-639-1414	chieffo.carla@gmail.com
National Agricultural Research Institute (NARI)	<i>Director General or NARI Representative</i>		
The Gambia Horse and Donkey Trust (GHDT)	Dr. Abdou Ceesay	220-995-6980	abdou.sunagie2002@yahoo.com
National Environmental Agency (NEA)	<i>NEA Representative</i>		
Ministry of Health (MoH)	<i>MoH Representative</i>		
Kombo Veterinary Service	Dr. Bart Goossens – Veterinarian	220-705-2728	
Laga Ndongo Taborr	Mr. Mosou Sarr – Animal Scientist and International Monitoring and Evaluation Consultant	220-996-4315 220-756-1663	mjsarr2002@yahoo.com
Ministry of Higher Education, Research, Science, and Technology (MoHERST)	Ms. Jainaba Jagne – Director of Research	220-902-2209 220-308-3308	moherst@gmail.com jjagne@moherst.org

Table 2. Percentage response frequencies to binary questions assessing consumer attitudes towards goat dairy (n = 29)

<i>Question</i>	<i>Response (%)</i>	
	<i>Yes</i>	<i>No</i>
A. Have you drank milk before?	100.0	0.0
B. Have you eaten yogurt before?	89.7	10.3
C. If available and affordable, would you buy goat milk?	96.6	3.4
D. If available and affordable, would you buy goat yogurt?	89.7	10.3
E. Would you pay \$75 DAL for 1 liter of goat milk?	65.5	34.5
F. Would you pay \$60 DAL for 0.5 liter of goat yogurt?	82.8	17.2
G. Did you know that goat milk can be healthier than cow milk?	50.0	50.0

Table 3. Percentage response frequencies to numerical response questions assessing demand for goat dairy (n = 28)

<i>Question</i>	<i>Response (%)</i>			
	<i>Daily</i>	<i>8-16</i>	<i>4</i>	<i>Fewer</i>
A. If available and affordable, how many times a month would you buy goat milk?	50.0	14.3	17.8	17.9
B. If available and affordable, how many times a month would you buy goat yogurt?	37.3	17.9	17.9	26.9

Table 4. Measures of success to ensure project accountability

<i>Measurement of Success</i>	<i>Target Value</i>	<i>Target Year</i>
Community Nutrition		
Liters of affordable milk per day	40.0 L	2020
Hospital Subsidization		
Number of inaccessible medications subsidized per month	?	?
Business Expansion		
- Processing cooperative establishment	--	?
- F1 lending program establishment	--	?
- Internally subsidized scale-up	--	?
- Model replication	--	?

Table 5. Points of achievement and target dates for completion

<i>Achievement</i>	<i>Year of Completion</i>
Building construction and breeding program onset	2017
Processing center establishment and dairy production onset	2018
Realization of self-sufficiency	2019
Evaluation of success and impact assessment	2020

Table 6. GGD staff and responsibilities

<i>Staff Member</i>	<i>Responsibilities</i>
Herd Manager	Goat feeding, basic veterinary care (vaccinations, deworming, castration, dehorning, treatment and recognition of basic ailments and infections), purchase and transport of feed and equipment, finance, payroll, budgeting, staff management
Milking/Processing Staff	Milking, pasteurization, processing, packaging, assisting herd manager, basic maintenance of processing equipment
Bwiam Market Vendor	Transport of dairy products to point of sale, sale of products, advertising and marketing
Maintenance	Building and equipment repairs and upkeep
Security	Theft prevention

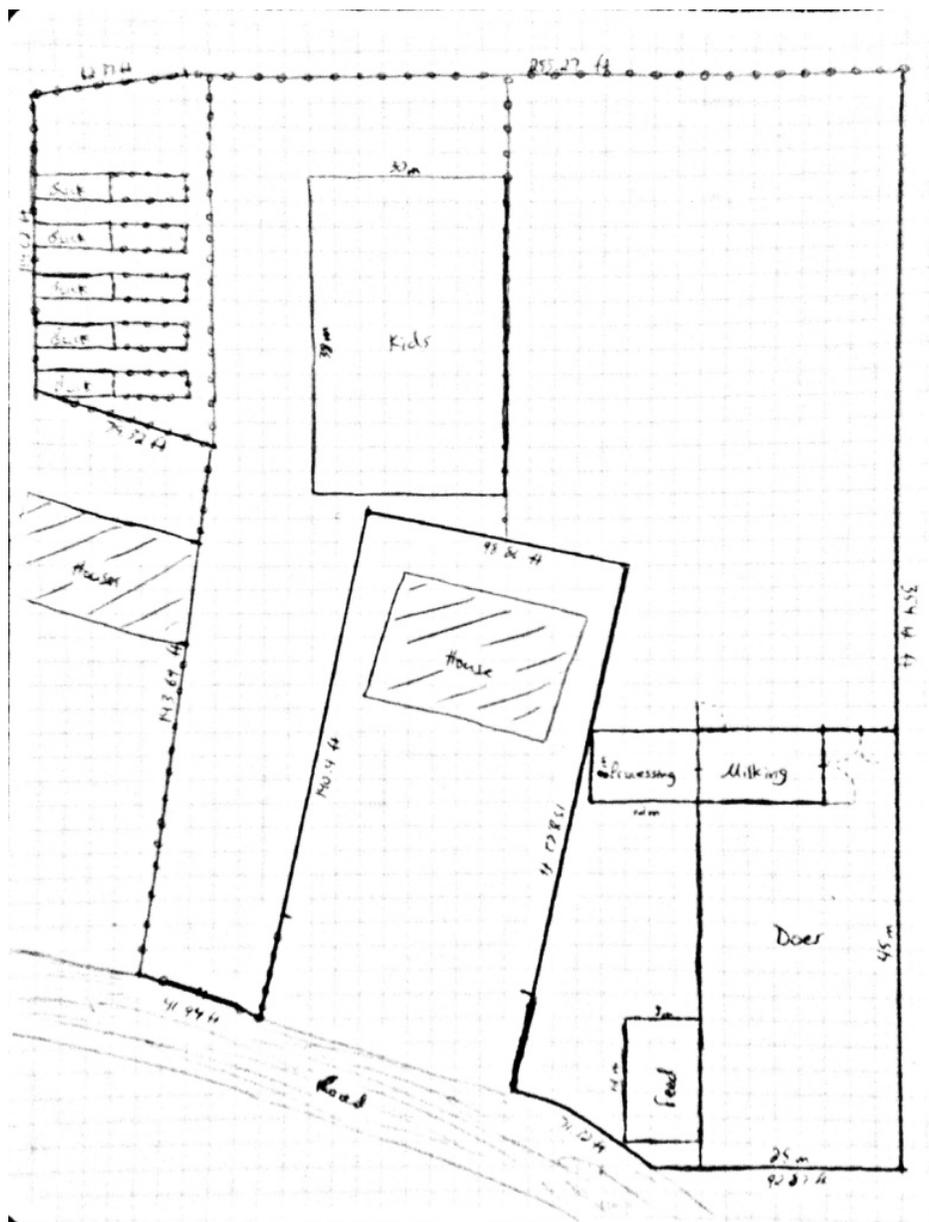
Figure 1. Property outline and farm layout

Figure 2. Doe shed building floorplan **to be completed**

Figure 3. Kid shed building floorplan **to be completed**

Figure 4. FAO Village Milk yogurt-making protocol



FAO CORPORATE DOCUMENT REPOSITORY

Title: Village milk processing...

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Part 4 APPROPRIATE TECHNOLOGY FOR THE MANUFACTURE OF DAIRY PRODUCTS

d) Yoghurt-making cultures

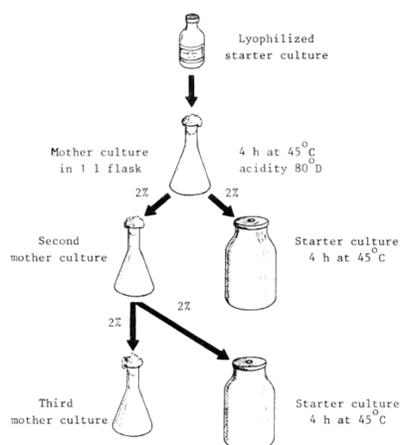
Starter cultures for yoghurt-making are thermophilic bacteria. They must be cultured therefore at a temperature of 40 – 45°C for three to four hours.

After heat treatment of the milk to which the yoghurt bacteria are to be added, the milk is cooled to 45°C and then poured into 1 litre bottles. These are then set into a water tank at 45°C to stabilize the bottled milk temperature.

The lyophilized commercial strain for yoghurt-making is then put into the bottles.

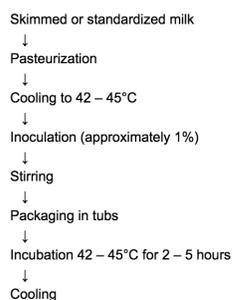
The bottles of milk are left in the water bath at 45°C for three to four hours.

The preparation of cultures for yoghurt-making is shown below.



IV YOGHURT

Steps in yoghurt-making are as follows:



Pasteurization and cooling are done in the cheese vat, or in a pan for smaller quantities.

For yoghurt-making, the dairy unit needs to have a large refrigerator or small cold storage area - this also applies to cream and butter. Another essential investment item is an incubator, and perhaps a hand bottle-capper. Yoghurt is usually sold in plastic tubs or in cartons of 120 or 125 ml.

The yoghurt-making process increases the amount of cream available. Thus the decision to produce yoghurt should be preceded by a cost benefit analysis.

Another technique is to let the yoghurt clot in the vat. It is then stirred prior to packaging.

Figure 5a. GGD FY17 Year Cash Flow Budget. Shaded regions indicate prices to be determined.

The Gambia Goat Dairy			
FY17 Cash Flow Budget			
January 2017 - January 2018			
	Detail Schedule	Budget (USD)	% of Total Income
Income			
Contributed Support			
Rotary International	unknown	2,000.00	6.25%
PennVet Food Animal Fellowship	unknown	0.00	0.00%
PennVet Inspiration Award		25,000.00	78.13%
Other Funding Organizations	unknown, needed	5,000.00	15.63%
Total Contributed Support		32,000.00	100.00%
Earned Revenues			
Milk sales	Sales begin 18 months after breeding program onset	0.00	0.00%
Yogurt sales	Sales begin 18 months after breeding program onset	0.00	0.00%
Buck sales	Sales begin 11 months after breeding program onset	0.00	0.00%
Doe sales	Sales begin 24 months after breeding program onset	0.00	0.00%
Manure sales	TBD	0.00	0.00%
Total Earned Revenues		0.00	0.00%
Total Income		\$ 32,000.00	100.00%
Capital Expenditures			
		\$ 7,752.26	24.23%
1-Equipment			
Hot water heater	for cleaning	350.00	1.09%
Water storage	to maintain water supply in dry season, 1 large tank	225.00	0.70%
Fencing	chain link, poles. Estimated 300m at \$3/m with poles	900.00	2.81%
Fence charger	S10 15-acre fence charger by Gallagher (product code G341404)	131.46	0.41%
Electric fence	Field guardian classic poly tape, 2x 200m @ \$70 each	140.00	0.44%
Electric fence installation materials	insulators, end tensioners, offsets	100.00	0.31%
Tools	rakes, shovels, etc.	200.00	0.63%
Truck	donated, shipping cost listed	3,000.00	9.38%
2-Buildings		0.00	0.00%
Doe shed	25 x 45m, ventilation, slatted floors, feeding and water troughs, sections		0.00%
Kid shed	30 x 38m, ventilation, slatted floors, feeding and water troughs, sections		0.00%
Stud sheds	with building materials left over from other structures. Individual shelters with runs	0.00	0.00%
Feed shed	raised slatter floors, no ventilation, protected		0.00%
3-Forages			
		0.00	0.00%
<i>Panicum maximum</i>	Transplanted from ITC plot at cost		0.00%
Lucaena	Seeds freely available	0.00	0.00%
Moringa	Branches from tree are planted	0.00	0.00%
Zizifus			0.00%
4-Husbandry costs			
		195.00	0.61%
Hoof trimmers	2 trimmers at \$30 each	60.00	0.19%
Dehorning equipment	electric disbudder	135.00	0.42%
5-Veterinary care			
		110.80	0.35%
Centrifuge	Hand crank centrifuge	85.00	0.27%
Microscope	student microscope provided	0.00	0.00%
CMT Paddle	4 paddles at \$6.45	25.80	0.08%
6-Breeding			
		2,400.00	7.50%
WAD females	40 females at \$60	2,400.00	7.50%
FY17 Expenses			
		\$ 26,396.88	82.49%
1-Equipment			
		6,065.00	18.95%
Cleaning supplies	brushes, bleach, chlorine detergent. Estimated \$90 a month	1,080.00	3.38%
Truck insurance and registration	yearly cost	125.00	0.39%
Fuel	estimated at \$405 per month by GGD Daily Profit Projection	4,860.00	15.19%
2-Utilities			
		0.00	0.00%
Replacement parts	estimated 1 years supply		0.00%
3-Labor			
		3,150.00	9.84%
Herd manager	feeding, daily care, vet care, finance, payroll, budget, feed and equipment purchase and transport	1,050.00	3.28%
Maintenance	infrastructure repairs	1,050.00	3.28%
Security	theft prevention	1,050.00	3.28%
4-Feed			
		7,105.44	22.20%
Hay and concentrate	\$14.80 per day for 5 months, then \$23.14	7,079.40	22.12%
Mineral Blocks	12 blocks per year @ \$2.17 per block	26.04	0.08%
5-Soil analysis services			
			0.00%
6-Advising services			
			0.00%
7-Veterinary care			
		4,806.44	15.02%
Deworming	\$6.89 USD per month	82.68	0.26%
PPR Vaccine	provided by DLS	0.00	0.00%
Pasteurella Vaccine (1x/year?)	calculated by GGD Daily Profit Projection	206.76	0.65%
Clostridium Vaccine			0.00%

Aflatoxin Feed Test (monthly)	calculated by GGD Daily Profit Projection	450.00	1.41%
Bloat remedy	Estimated 2 bottles of tympasol	17.50	0.05%
Mastitis antibiotics	Estimated one bottle of oxytetracycline spray per year	6.25	0.02%
Diminazine aceturate (tryps)	Estimated 1 box per year containing 10 sachets	8.75	0.03%
Calcium			0.00%
Cocciostats			0.00%
Amatrax (pour on insect repellent)			0.00%
Emergency service			0.00%
CMT Concentrate	Estimated 2 bottles of concentrated reagent per year, at \$9.25	18.50	0.06%
PCV Tubes	Estimated \$100 per month, for ~30 uses	1,200.00	3.75%
Fecal solution	Estimated \$25 per month	300.00	0.94%
Slides	with cover glass, estimated \$5 per month for ~70 uses	60.00	0.19%
Syringes	Estimated \$15 per month, for ~30 uses	180.00	0.56%
Needles	Estimated \$15 per month, for ~30 uses	180.00	0.56%
EDTA Tubes	Estimated \$100 per month, for ~30 uses	1,200.00	3.75%
Gauze	Estimated \$8 per week	416.00	1.30%
Alcohol	Estimated \$25 per month	300.00	0.94%
Nitrile gloves (vet care)	Estimated \$15 per month	180.00	0.56%
Q fever ELISA test	CHEKIT-Q-FEVER test from IDEXX		0.00%
8-Marketing expenses	stall for vendor in market (300 DAL per month)	90.00	0.28%
9-Administrative costs	cell phone, printing	480.00	1.50%
10-Flights	Round trip NYC to Banjul, 2 people	3,200.00	10.00%
11-Living Expenses	\$250 per month, for 6 months	1,500.00	4.69%
Total Expenses		\$ 34,149.14	106.72%
Net Income		-\$ 2,149.14	-6.72%

Figure 5b. GGD FY18 Year Cash Flow Budget. Shaded regions indicate prices to be determined.

The Gambia Goat Dairy			
FY18 Cash Flow Budget			
January 2018 - January 2019			
	Detail Schedule	Budget (USD)	% of Total Income
Income			
Contributed Support			
Rotary International	unknown	0.00	0.00%
PennVet Food Animal Fellowship	unknown	0.00	0.00%
PennVet Inspiration Award		25,000.00	46.68%
Other Funding Organizations	unknown, needed	0.00	0.00%
Total Contributed Support		25,000.00	46.68%
Earned Revenues			
Milk sales	Sales begin 18 months after breeding program onset	1,566.00	2.92%
Yogurt sales	Sales begin 18 months after breeding program onset	21,060.00	39.33%
Buck sales	Sales begin 11 months after breeding program onset	5,927.60	11.07%
Doe sales	Sales begin 24 months after breeding program onset	0.00	0.00%
Manure sales	TBD	0.00	0.00%
Total Earned Revenues		28,553.60	53.32%
Total Income		\$ 53,553.60	100.00%
Capital Expenditures			
		\$ 13,623.95	25.44%
1-Equipment			
		13,523.95	25.25%
Milking equipment			
Strip milk cups	Aluminum w/ stainless steel screen insert, 3 cups	45.60	0.09%
Spray bottles	3 bottles	29.55	0.06%
Milking pails	4 pails	115.80	0.22%
Automatic milker			0.00%
Milk processing			
Refrigeration	1 refrigerator	500.00	0.93%
Pasteurization	Milk-Pro Pasteurization System	10,000.00	18.67%
Lab coats	3 lab coats	48.00	0.09%
Packaging and storage	50L milk cans, transport crates	400.00	0.75%
Milk funnel	funnel with filter	50.00	0.09%
Lactodensitometers	2-3, with glass graduated cylinders to measure milk density	75.00	0.14%
Dornic acidimeter	with pheno-phthalein and NaOH to measure milk acidity	50.00	0.09%
Butyrometer	with sulfuric acid, amyl alcohol, and centrifuge to measure milk fat (estimate from FAO)	1,000.00	1.87%
Thermometer	2 to 3	10.00	0.02%
Spring scale	50 kg spring scale	20.00	0.04%
Culture flasks	4 1000mL laboratory flasks	40.00	0.07%
Culture bottles	4 1000mL laboratory bottles	40.00	0.07%
Yogurt incubator			0.00%
Yogurt filler/sealer	Including shipping via DHL from India (Blenzor company in Mumbai)	750.00	1.40%
Hot water heater	for cleaning	350.00	0.65%
2-Buildings			
Pasteurization/processing shed	tile wall and floors, electricity, plumbing, off milking parlor		0.00%
Milking Parlor	large existing structure, needs stantions, electric, plumbing, as part of doe shed		0.00%
3-Utilities			
		0.00	0.00%
Plumbing	to milking parlor and pasteurization shed		0.00%
Electric	to milking parlor and pasteurization shed		0.00%
Sinks (2)	for milking parlor and pasteurization shed		0.00%
4-Administrative costs			
		100.00	0.19%
Printer		100.00	0.19%
FY18 Expenses			
		\$ 28,813.58	53.80%
1-Equipment			
		6,440.00	12.03%
Milking equipment			
Iodine	three 1 gallon jugs of 7% iodine	225.00	0.42%
Paper towels	estimated 1 years supply	50.00	0.09%
Milk processing			
Sachets			0.00%
Yogurt cartons			0.00%
Yogurt cultures			0.00%
Masks	Estimated \$15 per month for 6 months	50.00	0.09%
Nitrile gloves (processing)	Estimated \$15 per month for 6 months	50.00	0.09%
Cleaning supplies	brushes, bleach, chlorine detergent. Estimated \$90 a month	1,080.00	2.02%
Truck insurance and registration	yearly cost	125.00	0.23%
Fuel	estimated at \$405 per month in GGD Daily Profit Projection	4,860.00	9.08%
2-Utilities			
		0.00	0.00%
Replacement parts	estimated 1 years supply		0.00%
3-Labor			
		2,925.00	5.46%

Herd manager	feeding, daily care, vet care, finance, payroll, budget, feed and equipment purchase and transport	525.00	0.98%
Milking and processing staff (2)	milking, pasteurization, processing, packaging	1,050.00	1.96%
Maintenance	infrastructure repairs	525.00	0.98%
Bwiam market vendor	sales, marketing	525.00	0.98%
Security	theft prevention	300.00	0.56%
4-Feed		8,472.14	15.82%
Hay and concentrate	calculated by GGD Daily Profit Projection, w/ daily feed cost of \$20.57	8,446.10	15.77%
Mineral Blocks	12 blocks per year @ \$2.17 per block	26.04	0.05%
5-Soil analysis services	NARI samples to US		0.00%
6-Advising services	For workshop series, certificates of completion etc. from DLS		0.00%
7-Veterinary care		4,806.44	8.98%
Deworming	\$6.89 USD per month	82.68	0.15%
PPR Vaccine		0.00	0.00%
Pasteurella Vaccine (1x/year?)	calculated by GGD Daily Profit Projection	206.76	0.39%
Clostridium Vaccine			0.00%
Aflatoxin Feed Test (monthly)	calculated by GGD Daily Profit Projection	450.00	0.84%
Bloat remedy	Estimated 2 bottles of tympasol	17.50	0.03%
Mastitis antibiotics	Estimated one bottle of oxytetracycline spray per year	6.25	0.01%
Diminazine aceturate (trysps)	Estimated 1 box per year containing 10 sachets	8.75	0.01%
Calcium			0.02%
Coccidiostats			0.00%
Amatrx (pour on insect repellant)			0.00%
Emergency service			0.00%
CMT Concentrate	Estimated 2 bottles of concentrated reagent per year, at \$9.25	18.50	0.03%
PCV Tubes	Estimated \$100 per month, for ~30 uses	1,200.00	2.24%
Fecal solution	Estimated \$25 per month	300.00	0.56%
Slides	with cover glass, estimated \$5 per month for ~70 uses	60.00	0.11%
Syringes	Estimated \$15 per month, for ~30 uses	180.00	0.34%
Needles	Estimated \$15 per month, for ~30 uses	180.00	0.34%
EDTA Tubes	Estimated \$100 per month, for ~30 uses	1,200.00	2.24%
Gauze	Estimated \$8 per week	416.00	0.78%
Nitrile gloves (vet care)	Estimated \$15 per month	180.00	0.34%
Alcohol	Estimated \$25 per month	300.00	0.56%
Q fever ELISA test	CHEKIT-Q-FEVER test from IDEXX		0.00%
8-Marketing expenses	stall for vendor in market (300 DAL per month)	90.00	0.17%
9-Administrative costs	internet, cell phone, ink	1,380.00	2.58%
10-Flights	Round trip NYC to Banjul, 2 people	3,200.00	5.98%
11-Living Expenses	\$250 per month, for 6 months	1,500.00	2.80%
Total Expenses		\$ 42,437.53	79.24%
Net Income		\$ 11,116.07	20.76%

Figure 5c. GGD FY19 Year Cash Flow Budget. Shaded regions indicate prices to be determined.

The Gambia Goat Dairy			
FY19 Cash Flow Budget			
January 2019 - January 2020			
	Detail Schedule	Budget (USD)	% of Total Income
Income			
Contributed Support			
Rotary International		0.00	0.00%
PennVet Food Animal Fellowship		0.00	0.00%
PennVet Inspiration Award		0.00	0.00%
Other Funding Organizations		0.00	0.00%
Total Contributed Support		0.00	0.00%
Earned Revenues			
Milk sales	Sales begin 18 months after breeding program onset	18,980.00	26.35%
Yogurt sales	Sales begin 18 months after breeding program onset	42,705.00	59.29%
Buck sales	Sales begin 11 months after breeding program onset	5,927.60	8.23%
Doe sales	Sales begin 24 months after breeding program onset	4,409.20	6.12%
Manure sales	TBD	0.00	0.00%
Total Earned Revenues		72,021.80	100.00%
Total Income		\$ 72,021.80	100.00%
Capital Expenditures			
		\$ 0.00	0.00%
FY19 Expenses			
		\$ 31,688.58	44.00%
1-Equipment			
Milking equipment		6,480.00	9.00%
Iodine	three 1 gallon jugs of 7% iodine	225.00	0.31%
Paper towels	estimated 1 years supply	50.00	0.07%
Milk processing			0.00%
Sachets			0.00%
Yogurt cartons			0.00%
Yogurt cultures			0.00%
Masks	Estimated \$15 per month for 6 months	50.00	0.07%
Nitrile gloves	Estimated \$15 per month for 6 months	90.00	0.12%
Cleaning supplies	brushes, bleach, chlorine detergent. Estimated \$90 a month	1,080.00	1.50%
Truck insurance and registration	yearly cost	125.00	0.17%
Fuel	estimated at \$405 per month in GGD Daily Profit Projection	4,860.00	6.75%
2-Utilities			
Replacement parts	estimated 1 years supply	0.00	0.00%
3-Labor			
Herd manager	feeding, daily care, vet care, finance, payroll, budget, feed and equipment purchase and transport	1,050.00	1.46%
Milking and processing staff (2)	milking, pasteurization, processing, packaging	2,100.00	2.92%
Maintenance	infrastructure repairs	1,050.00	1.46%
Bwiam market vendor	sales, marketing	1,050.00	1.46%
Security	theft prevention	600.00	0.83%
4-Feed			
Hay and concentrate	calculated by GGD Daily Profit Projection, w/ daily feed cost of \$20.57	8,446.10	11.73%
Mineral Blocks	12 blocks per year @ \$2.17 per block	26.04	0.04%
5-Soil analysis services			
	NARI samples to US		0.00%
6-Advising services			
	For workshop series, certificates of completion etc. from DLS		0.00%
7-Veterinary care			
Deworming	\$6.89 USD per month	82.68	0.11%
PPR Vaccine		0.00	0.00%
Pasteurella Vaccine (1x/year?)	calculated by GGD Daily Profit Projection	206.76	0.29%
Clostridium Vaccine			0.00%
Aflatoxin Feed Test (monthly)	calculated by GGD Daily Profit Projection	450.00	0.62%
Bloat remedy	Estimated 2 bottles of tympasol	17.50	0.02%
Mastitis antibiotics	Estimated one bottle of oxytetracycline spray per year	6.25	0.01%
Diminazine aceturate (trysps)	Estimated 1 box per year containing 10 sachets	8.75	0.01%
Calcium			0.01%
Coccidiostats			0.00%
Amatrx (pour on insect repellent)			0.00%
Emergency service			0.00%
CMT Concentrate	Estimated 2 bottles of concentrated reagent per year, at \$9.25	18.50	0.03%
PCV Tubes	Estimated \$100 per month, for ~30 uses	1,200.00	1.67%
Fecal solution	Estimated \$25 per month	300.00	0.42%
Slides	with cover glass, estimated \$5 per month for ~70 uses	60.00	0.08%
Syringes	Estimated \$15 per month, for ~30 uses	180.00	0.25%
Needles	Estimated \$15 per month, for ~30 uses	180.00	0.25%
EDTA Tubes	Estimated \$100 per month, for ~30 uses	1,200.00	1.67%
Gauze	Estimated \$8 per week	416.00	0.58%

Nitrile gloves	Estimated \$15 per month for 6 months	90.00	0.12%
Alcohol	Estimated \$25 per month	300.00	0.42%
Q fever ELISA test	CHEKIT-Q-FEVER test from IDEXX		0.00%
8-Marketing expenses	stall for vendor in market (300 DAL per month)	90.00	0.12%
9-Administrative costs	internet, cell phone, ink	1,380.00	1.92%
10-Flights	Round trip NYC to Banjul, 2 people	3,200.00	4.44%
11-Living Expenses	\$250 per month, for 6 months	1,500.00	2.08%
Total Expenses		\$ 31,688.58	44.00%
Net Income		\$ 40,333.22	56.00%

Figure 6. GGD Daily Profit Projection. Shaded regions indicate prices to be determined.

Daily Production Cost			
Item	Daily cost (USD)	% of Daily Income	
Feed - Lactating Females			
Groundnut hay	\$ 9.74	5.81%	
Millet bran	\$ 0.42	0.25%	
Rice bran	\$ 1.14	0.68%	
Cottonseed cake	\$ 0.76	0.45%	
Groundnut cake	\$ 0.76	0.45%	
Sesame cake	\$ -	0.00%	
Cous bran	\$ -	0.00%	
Total feed cost of lactating females	\$ 12.82	7.64%	
Feed - Pregnant Females			
Groundnut hay	\$ 1.51	0.90%	
Millet bran	\$ 0.07	0.04%	
Rice bran	\$ 0.18	0.10%	
Cottonseed cake	\$ 0.12	0.07%	
Groundnut cake	\$ 0.12	0.07%	
Sesame cake	\$ -	0.00%	
Cous bran	\$ -	0.00%	
Total feed cost for pregnant females	\$ 1.98	1.18%	
Feed - Bucks			
Groundnut hay	\$ 1.10	0.66%	
Millet bran	\$ 0.04	0.02%	
Rice bran	\$ 0.11	0.06%	
Cottonseed cake	\$ 0.07	0.04%	
Groundnut cake	\$ 0.07	0.04%	
Sesame cake	\$ -	0.00%	
Cous bran	\$ -	0.00%	
Total feed cost for bucks	\$ 1.38	0.82%	
Feed - Kids			
Groundnut hay	\$ 6.96	4.15%	
Millet bran	\$ -	0.00%	
Rice bran	\$ -	0.00%	
Cottonseed cake	\$ -	0.00%	
Groundnut cake	\$ -	0.00%	
Sesame cake	\$ -	0.00%	
Cous bran	\$ -	0.00%	
Total feed cost for kids	\$ 6.96	4.15%	
Total daily feed cost	\$ 23.14	13.79%	
Item	Monthly Cost (USD)	Daily cost (USD)	% of Total Income
Labor			
Herd manager	\$ 87.50	\$ 2.92	1.74%
Milking/processing staff	\$ 87.50	\$ 2.92	1.74%
Milking/processing staff	\$ 87.50	\$ 2.92	1.74%
Bwiam market vendor	\$ 87.50	\$ 2.92	1.74%
Maintenance	\$ 87.50	\$ 2.92	1.74%
Security	\$ 87.50	\$ 2.92	1.74%
Total labor cost	\$ 17.50	\$ 17.50	10.43%
Veterinary Care			
Deworming	\$ 6.89	\$ 0.23	0.14%
PPR Vaccine	\$ -	\$ -	0.00%
Pasteurella Vaccine (1x?)	\$ 17.23	\$ 0.57	0.34%
Clostridium Vaccine	\$ -	\$ -	0.00%
Aflatoxin Feed Test (monthly)	\$ 37.50	\$ 1.25	0.74%
Dimbasul (bloat remedy)	\$ 1.46	\$ 0.05	0.03%
Mastitis antibiotics	\$ 0.52	\$ 0.02	0.01%
Diminazine aceturate (tryps)	\$ 0.73	\$ 0.02	0.01%
Calcium	\$ -	\$ -	0.00%
Coccidiostats	\$ -	\$ -	0.00%
Amatraz (pour on insect repellent)	\$ -	\$ -	0.00%
Emergency service	\$ -	\$ -	0.00%
CMT Reagent	\$ 1.54	\$ 0.05	0.03%
PCV Tubes	\$ 100.00	\$ 3.33	1.99%
Fecal Solution	\$ 25.00	\$ 0.83	0.50%
Slides	\$ 5.00	\$ 0.17	0.10%
Syringes	\$ 15.00	\$ 0.50	0.30%
Needles	\$ 15.00	\$ 0.50	0.30%
EDTA Tubes	\$ 100.00	\$ 3.33	1.99%
Gauze	\$ 32.00	\$ 1.07	0.64%
Nitrile gloves (vet care)	\$ 15.00	\$ 0.50	0.30%
Alcohol	\$ 25.00	\$ 0.83	0.50%
Total veterinary cost	\$ 13.26	\$ 13.26	7.90%
Transport			
Gas (1.5 60L tanks/week @ 45dal/L)	\$ 405.00	\$ 13.50	8.04%
Insurance and registration	\$ 10.42	\$ 0.35	0.21%
Total transport cost	\$ 13.85	\$ 13.85	8.25%
Breeding			
Liquid nitrogen	\$ -	\$ -	0.00%
Saanen semen	\$ 583.33	\$ 19.44	11.59%
Transport cost	\$ -	\$ -	0.00%
Nitrile gloves (breeding)	\$ 15.00	\$ 0.50	0.30%
Lubricant	\$ 20.00	\$ 0.67	0.40%
Total breeding cost	\$ 20.61	\$ 20.61	12.28%
Marketing			
Market stall rent	\$ 7.50	\$ 0.25	0.15%
Radio advertisements	\$ -	\$ -	0.00%
Media publications	\$ -	\$ -	0.00%

Daily Income				
Item	Price per L (USD)	Liters sold	Daily Sales (USD)	% of Total Income
Milk Sales				
Sachets	\$ 0.90	25	\$ 22.50	13.41%
Total milk sales			\$ 22.50	13.41%
Yogurt Sales				
Cartons	\$ 2.34	50	\$ 117.00	69.71%
Total yogurt sales			\$ 117.00	69.71%
Goat Sales				
Buck sales	\$ 75.63	0.2148	\$ 16.24	9.68%
Doe sales	\$ 56.25	0.2148	\$ 12.08	7.20%
Total goat sales			\$ 28.33	16.88%
Manure Sales				
Manure			\$ -	0.00%
Total manure sales			\$ -	0.00%
Hide Sales				
Hides			\$ -	0.00%
Total hide sales			\$ -	0.00%
Total Income			\$ 167.83	100.00%
Profit Margin			\$ 54.29	32.35%
Total Income per Milking Goat			\$ 3.36	2.00%
Profit Margin per Milking Goat			\$ 1.09	0.65%
Total Income per Liter Milk			\$ 1.68	1.00%
Profit Margin per Liter Milk			\$ 0.54	0.32%

Parameters	
Number of milking goats	50.00
Average number of lactating females	43.30
Average number of pregnant females	6.70
Number of bucks	5.00
Average number of kids on farm	77.33
Kiddings per year	1.50
Average milk yield (L/day)	2.00
Average buck bodyweight (kg)	55.00
Average pregnant female bodyweight (kg)	45.00
Average lactating female bodyweight (kg)	45.00
Average kid bodyweight (kg)	22.50
Hospital subsidy as percentage of daily sales (%)	5%
Subsidized sachets given freely to patients per day	25
Buck selling price per kg (USD)	\$ 1.38
Doe selling price per kg (USD)	\$ 1.25
Groundnut hay price per kg (USD)	\$ 0.10
Millet bran price per kg (USD)	\$ 0.13
Rice bran price per kg (USD)	\$ 0.35
Cottonseed cake price per kg (USD)	\$ 0.35
Groundnut cake price per kg (USD)	\$ 0.35
Sesame cake price per kg (USD)	\$ 0.13
Cous bran price per kg (USD)	\$ 0.13

Diet Formulation		
Lactating Females		
	Kg concentrate:	0.250
	Hay as % bodyweight:	5.00%
Feed	Concentrate Makeup	Daily Intake (kg)
Groundnut hay	--	2.25
Millet bran	30.00%	0.08
Rice bran	30.00%	0.08
Cottonseed cake	20.00%	0.05
Groundnut cake	20.00%	0.05
Sesame cake	0.00%	0.00
Cous bran	0.00%	0.00
Pregnant Females		
	Kg concentrate:	0.250
	Hay as % bodyweight:	5.00%
Feed	Concentrate Makeup	Daily Intake (kg)
Groundnut hay	--	2.25
Millet bran	30.00%	0.08
Rice bran	30.00%	0.08
Cottonseed cake	20.00%	0.05
Groundnut cake	20.00%	0.05
Sesame cake	0.00%	0.00
Cous bran	0.00%	0.00
Bucks		
	Kg concentrate:	0.200
	Hay as % bodyweight:	4.00%
Feed	Concentrate Makeup	Daily Intake (kg)
Groundnut hay	--	2.20
Millet bran	30.00%	0.06
Rice bran	30.00%	0.06
Cottonseed cake	20.00%	0.04
Groundnut cake	20.00%	0.04

Other advertising costs		\$ -	0.00%
Total marketing cost		\$ 0.25	0.15%
Materials			
Mineral block	\$ 2.17	\$ 0.07	0.04%
Milk sachets	\$ -	\$ -	0.00%
Yogurt cartons	\$ -	\$ -	0.00%
Sponges and brushes	\$ 20.00	\$ 0.67	0.40%
Bleach	\$ 30.00	\$ 1.00	0.60%
Detergent	\$ 30.00	\$ 1.00	0.60%
Paper towels	\$ 30.00	\$ 1.00	0.60%
Masks	\$ 15.00	\$ 0.50	0.30%
Nitrile gloves (processing)	\$ 15.00	\$ 0.50	0.30%
Iodine	\$ 18.75	\$ 0.63	0.37%
Milk quality assessment reagents	\$ -	\$ -	0.00%
Total materials cost		\$ 5.36	3.20%
Maintenance			
Building repairs estimate	\$ 60.00	\$ 2.00	1.19%
Milk-Pro replacement parts estimate	\$ 60.00	\$ 2.00	1.19%
Equipment repair parts estimate	\$ 100.00	\$ 3.33	1.99%
Total maintenance cost		\$ 7.33	4.37%
Hospital			
Medication subsidy	\$ 251.74	\$ 8.39	5.00%
Total hospital cost		\$ 8.39	5.00%
Administrative			
Internet	\$ 75.00	\$ 2.50	1.49%
Cell phone	\$ 20.00	\$ 0.67	0.40%
Paper, stationary, ink	\$ 20.00	\$ 0.67	0.40%
Total administrative cost		\$ 3.83	2.28%
Total Cost		\$ 113.54	67.65%
Cost per Milking Goat		\$ 2.27	1.35%
Cost per Liter Milk		\$ 1.14	0.68%

Sesame cake	0.00%	0.00
Cous bran	0.00%	0.00
Kids		
Kg concentrate:		0.000
Hay as % bodyweight:		4.00%
Feed	Concentrate Makeup	Daily Intake (kg)
Groundnut hay	--	0.90
Millet bran	30.00%	0.00
Rice bran	30.00%	0.00
Cottonseed cake	20.00%	0.00
Groundnut cake	20.00%	0.00
Sesame cake	0.00%	0.00
Cous bran	0.00%	0.00

Notes	
Assumes all milk produced is sold	
Assumes half the sachets produced daily are given without charge to needy patients	
Does not account for variance in yield between goats	
Assumes 1/2 of all milk produced is converted to an equal volume of yogurt	
Estimates average number of lactating females based on 8 month kidding cycle	
Estimates average number of kids based on sale at 6 months	
Assumes all F2 kids are sold	