Tropical Agricultural Research and Higher Education Center

POSTGRADE SCHOOL

Cost-benefit analysis of manure applications on specialized dairy farms in the highlands and lowlands of Costa Rica

Graduation work submitted for consideration by the Graduate School as a requirement to choose the degree of
Master in Sustainable Business Administration and Development

By

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This graduation work has been accepted in its present form by the Graduate School of CATIE and approved by the student advisory committee, as a requirement to opt for the degree of

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Contents Table

List of acronyms, abbreviations and units

Nitrous Oxide	N_2O
Carbon Dioxide	CO_2
Cost-Benefit Analysis	CBA
Nitrogen	N
Intensive Specialized Highland Dairy	IS-HD
Intensive Specialized Lowland Dairy	IS-LD
Tropical Agricultural Research Higher Education Center	CATIE
Sustainable futures for the Costa Rica dairy sector	SusCoRiDa
Bangor University	BU
Costa Rica	CR
Global Challenges Research Fund	GCRF
Phosphorus	P
Potassium	K
Organic Matter	OM
Greenhouse gas	GHG
Manure System Model	PSM
Annual Average Population	AAP
Net Energy for Maintenance	NEM
Net Energy for Activity	NEA
Net Energy for Lactation	NEL
Net Energy for Pregnancy	NEP
Ratio of Net Energy for Maintenance	REM
Gross Energy	GE
Dry Matter Intake	DMI
Volatile Solids	VS
Nitrogen	N
Phosphorus	P
Milk Urea Nitrogen	MUN
Confidence Interval	CI

List of tables

List of figures

1. INTRODUCTION

1.1 Background

In the past decades, the agriculture and livestock sector has been using more organic and chemical fertilizers to grow plants and forages (Lu and Tian 2017). Increased use of fertilizers has increased crop and forage production but also elevated the risk of nutrient loss to the environment (Dunne *et al*. 2005). Livestock numbers have increased to meet global demand for milk and beef and thus have manure production and applications (FAO 2018).

One of the main protagonist gases leading to global climate change is nitrous oxide (N_2O), it is 265 times more potent than Carbon Dioxide (CO_2). Since it is very potent is important to consider especially in manure management systems such as purine irrigation. According to scientists it has a long life span in comparison to CO_2, it persists in the atmosphere around 114 years therefore by reducing it an improvement on the greenhouse gas issue can occur (Cole et al. 1997, ICF 2002, IPCC 2006). Manure management makes up 5% of the emissions of N_2O it is one of the principal sources. The following figure 1 shows the N_2O emissions from agriculture (Figure 1).

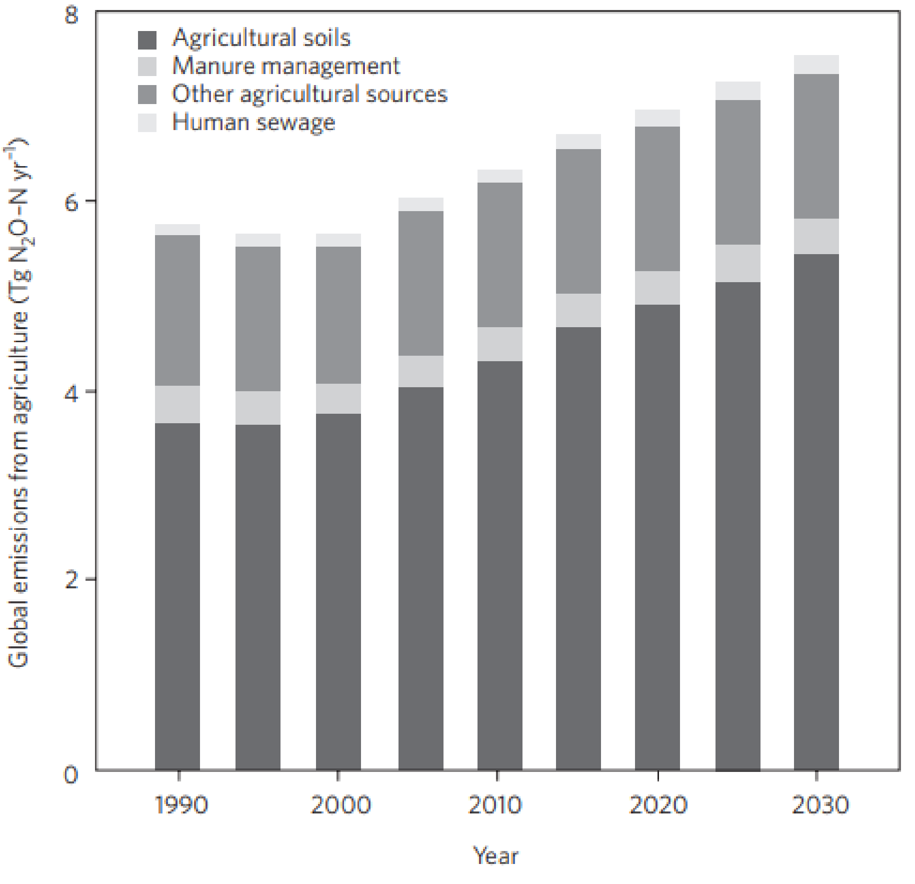

Figure 1. Nitrous oxide N2O emissions from agriculture

Source: From (Reay, Dave S. et al. 2012).

Correctly manure management can improve soil health (Dellaguardia 2009), but wrong manure managing can lead to negative consequences such as water and soil contamination (Millner 2009, Miron et al. 2011, Natvig et al. 2002). Nitrogen (N) flow in dairies is characterized by different N inputs such as fertilizer, purines[1] and legume fixation; and N outputs in form of milk, meat, and manure (Figure 2).

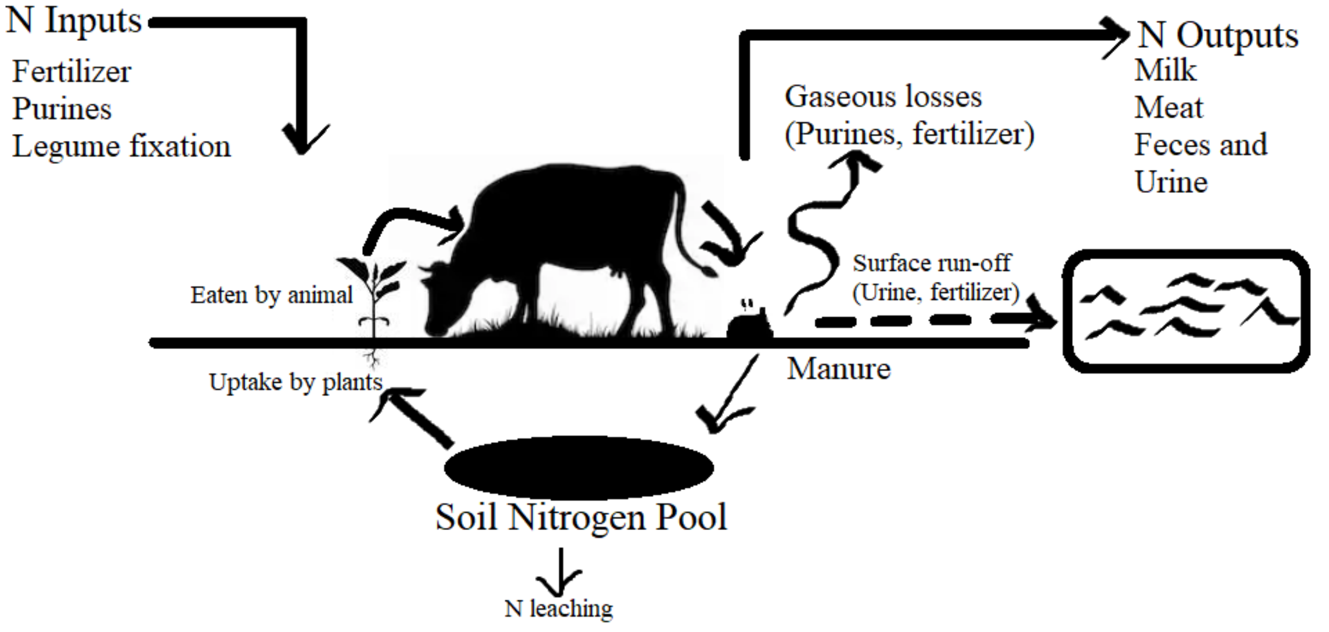

Figure 2. Nitrogen (N) flow in dairy farms with inputs and outputs

Source: Own elaboration based on nitrogen cycle from WRC (2019).

The objective of this study is to estimate the value of manures for dairy farm pastures through a cost-benefit analysis (CBA) by quantifying manure- N content and costs for manure application. This work focuses on Intensive Specialized Highland Dairy (IS-HD) and Intensive Specialized Lowland Dairy (IS-LD). The IS-HD and IS-LD dairy types encompass the bulk of milk production in Costa Rica (CR) (CNPL 2019).

The objective of using purines system is to give a correct use to manure because if not otherwise it would end in rivers, lakes or other water sources (Dellaguardia 2009, Zhao et al. 2001, Sheriff 2005). Therefore, the use of purines in the fields is a safe way to return nutrients to the fields (University of Nebraska 2002, Haynes and Naidu 1998).

The aim of this study is to evaluate the profitability of purine irrigation by tubes and canons. We elaborated two models that represent the farms in the two regions mentioned above. A CBA study was conducted on these models to evaluate the viability and feasibility of manure applications.

[1] Purines are defined as livestock feces and urine, combined with wash water from the milking parlor and livestock housing.

This paper evaluates an agricultural practice used in Costa Rican dairies, as an aspect of a larger project called: "Sustainable futures for the Costa Rica dairy sector: Optimizing environmental and economic outcomes" (SusCoRiDa).

This joint project between Bangor University (BU), Rothamsted Research, and CATIE (2018) initiated the SusCoRiDa project, which strives for the evaluation and improvement of dairy management in CR, based on three goals:

- Improving livelihoods and rural incomes;
- Reducing greenhouse gas emissions and nutrient losses; and
- Adapting and building resilience to climate change.

The SusCoRiDa project responds to a need of the CR government for sustainable dairy management the Biotechnology and Biological Sciences Research Council (BBSRC) and the Global Challenges Research Fund (GCRF) are funding agencies for this initiative. The aim of the SusCoRiDa projects is to propose sustainable futures to aid the Costa Rican dairy industry.

1.2 Justification

The Costa Rican dairy industry has set the goals of managing soils for long term viability and preserving natural resources, as well as improving short and long-term profits (Chacón et al. 2015). One way of improving nutrient cycling efficiency in farms is by enhancing pasture manure management (Klausner *et al.* 1998). In addition, manure applications might lead to soil improvement and increased forage yields and qualities (Haynes and Williams 1992, Manna *et al.* 2007).

Manure usage is an important part of sustainable dairy farming, since discharging manure as a waste product instead of applying it to pastures or other agricultural land can cause excess loss of nutrients that not only harm water bodies but also increase fertilizer needs at the farm level (Oquist *et al*. 2007, Madison *et al.* 1995, Haynes and Naidu 1998). This study is important because it evaluates the costs and benefits of manure applications (Ávalos *et al.* 2016, Dellaguardia, 2009).

Costa Rica has been particularly vulnerable to historical price variability in chemical fertilizers (MEIC 2014). The use of chemical fertilizers has been related to an increase of N_2O emissions (Kanter *et al*. 2016, Hasegawa and Matsuoka 2010, Snyder *et al.* 2014, Reay *et al.* 2012) and contamination of superficial and underground waters with nitrates (Addiscott 2005, Cooke *et al.* 1957, Zaldívar 1977). On the other hand the scientific community has enumerated the benefits of manure applications, such as N availability and improvement of the soil structure (Haynes and Naidu 1998, Baldi and Toselli 2013, Mosaddeghi *et al*. 2009), the costs and benefits of manure applications to improve pastures and soils on Costa Rican dairy farms needs to be quantified. An economic evaluation of manure use will help farmers and government to understand and decide if this practice can help a sustainable dairy transition.

One of the main objectives in the SusCoRiDa project is to calculate economic balances, such as CBA and application of sensitivity analyses to best management practices and technologies that represent trends in dairy intensification (SusCoRiDa 2018). Efficient manure management is likely to improve pastural soils, decrease dairy farm costs and make dairy farming more sustainable (Ávalos *et al.* 2016). The objective of the present study is to conduct a CBA of manure applications on Costa Rica dairy farms with the aim of investigating if the application of manures is profitable, which would help to encourage such use.

2. OBJECTIVES

2.1 General objective

Analyze cost-benefit of applying manure in selected farms of the IS-HD and IS-LD milking regions.

2.2 Specific objectives

- Deriving baseline parameters of farm type in selected milking regions, standardizing two average farms.
- Developing a standard model for manure application, which is choosing one system of purine irrigation.
- Analyzing and comparing differences in economic outcomes of purine irrigation between IS-HD and IS-LD in Costa Rica.

3. FRAME OF REFERENCE

3.1 Purines

Manures are the captured feces and urine produced by livestock in the stable during feeding and milking, combined with the wash water from the milking parlor and stable. Slurry/Purine applications have been of great importance for soil nutrition and crop and forage yields. A modern and widely used tendency is to use synthetic inputs with the goal of improving plant production, nevertheless organic agriculture supports manure application as an important practice in plant nutrition and improving soil composition (Dellaguardia 2009, Lory and Massey 2008).

The quantity and quality of nutrients available in manures is related to the diet of the animals and the amount of water in the mixture (NRCS 2003). The treatment of manures is a latent issue in CR, because according to the National Livestock Survey (INEC, 2017), 9,664 dairy farms operate in the country and 57% of these farms do not apply manures appropriately and discard it instead.

3.2 Advantages and disadvantages of manure applications

Manure contains nutrients essential for plants, such as N, phosphorus (P), and potassium (K), and has been described as an excellent "organic" fertilizer (McKenzie 2008, Salas and Hernandez 2008). It has beneficial properties for soil improvement and amendment through the addition of organic matter (OM), which increases soil tilth, structure and texture (Darwish *et al.* 1995, Dellaguardia 2009). Increased soil OM increases water holding capacities, improves water infiltration and reduces evaporation (Khaleel *et al*. 1981, Dellaguardia 2009).

Manure applications also enhance root development and increases the appearance of soil aggregates that reduce soil erosion (Baldi and Toselli 2013, Mosaddeghi *et al.* 2009). Appropriate manure applications can improve soil cation exchange capacity and pH levels (Dellaguardia 2009). Furthermore, manure applications can be beneficial for growth of soil organisms, because manure contains many natural substances and organisms which are needed for long-term health of the soil ecosystem (Dellaguardia 2009, University of Nebraska 2002).

Manure applications have been shown to not only improve soil fertility, but also to increase carbon sequestration in soil and to mitigate greenhouse gases (Cabrera *et al*. 2002, Lal 2004, 2004, Smith and Powlson 2000, Su *et al*. 2006, Dellaguardia 2009). In addition, the application of manure instead of commercially produced fertilizers can reduce N_2O and CO_2, because it reduces the emissions associated with fertilizer production (Chadwick *et al.* 2011).

Poorly managed manure is harmful to the environment because it can lead to runoff of excess nutrients and cause eutrophication, which increases algae growth in water bodies that later die and generate conditions of hypoxia, killing all aquatic life (David Letson 1996, Oquist *et al.* 2007). In addition, it can increase N_2O emissions (ICF 2002). Good manure management is regarded as a good practice in livestock farms that not only increase farm profit but also reduce environmental externalities (FAO 2018).

Two main types of manure management systems, the housing system is where manure management is necessary because it is done generally in places where exists cold winters with no pasture growth (Salazar Sperberg y Agr 2010). In this housing system all manure must be managed in order to function properly, on the other hand there exist systems where manure management is more optional such as pasture based systems where most of the manure is excreted on the pasture in form of dung and urine rather than in livestock housing (Van Horn et al. 1993).

According to Teenstra *et al.* (2014), manure contains OM and essential nutrients beneficial for crops, plants, microorganisms, fungi, insects, birds, mammals, and reptiles. However, badly managed manure or discharging manure to water bodies can destroy pristine watersheds (Zhao *et al.* 2001). As manure nutrient content varies, farmers tend to overapply manures, which can lead to lower forage yields as well as environmental pollution (Sheriff 2005).

Bad manure management or manure discharge into waterbodies have an increased risk of pollution. The adoption of best manure management practices reduces the risk of polluting pristine watersheds (Oquist *et al.* 2007, Correll *et al.* 1998).

Some studies suggest that good manure management is profitable, while other studies suggest that fertilizer applications are more profitable. A review of 14 international long-term studies (20 -120 years) concluded that manure applications only improve soil productivity when hundreds of tons are added over several years but because of excessive accumulation of nutrients, water quality can diminish. However, they concluded that manures is better to improve soil qualities than a chemical fertilizer (Edmeades 2003). Further advantages and disadvantages of manure applications are shown in Table 1.

Table 1. Advantage and Disadvantage of manure applications

Advantage[1]	**Disadvantage**
Contains N, P, K and OM (Haynes and Naidu 1998)	High transportation costs (Keplinger and Hauck 2006)
Betters soil tilth, structure and texture (Haynes and Naidu 1998)	Risk of excessive nutrient applications (Correll *et al.* 1998)
Increases water holding capacities (Khaleel *et al.* 1981)	Risk of P and N contamination of water bodies (Zhao *et al.* 2001)
Reduces soil erosion (Baldi and Toselli 2013)	Nutrient predictability is difficult (Sheriff 2005)
Reduces evaporation (Dellaguardia 2009)	Nutrient content is low (Sheriff 2005)

Enhances root development (Mosaddeghi *et al.* 2009)	Applications limited by rain (Keplinger and Hauck 2006)
Improves water infiltration (Khaleel *et al*. 1981)	High ammonia volatilization (ICF 2002)
Improves phosphate recycling (University of Nebraska 2002)	Nutrient losses prone to rain and terrain angle (Lory and Massey 2006)
Improves soil pH levels (Dellaguardia 2009)	Rainfall may interfere with nutrient quantity in uncovered storage? (Sheriff 2005)
Improves long-term soil health (University of Nebraska 2002)	

[1]N: Nitrogen; P: Phosphorus; K: Potassium; OM: Organic Matter

3.3 Economic value of manure

Livestock manure has an economic value associated to nutritional content (N, P, K and other macro and micro minerals), and OM, which is associated with betters soil tilth, structure, and texture (Haynes and Naidu 1998) as well as intrinsic effects (root development, soil pH levels, pore space, and microbial activity; Dellaguardia 2009) that contribute to the improvement of pastures (Madison *et al.* 1995).

Manure applications can reduce costs associated to chemical fertilizers (Ávalos *et al.* 2016, Camacho and Salas 2008). Manure management plans can increase the value for farmers because they optimize applications based on pasture nutrient requirements and thus prevent excessive application of nutrients leading to nutrient losses and environmental contamination (Lory and Massey 2006). However, an important economic issue of manure application is the transportation costs to the fields, because it has lower nutrient value per ton, then synthetic fertilizer. Thus, causing higher transportation costs compared with inorganic fertilizers (Keplinger and Hauck 2006).

3.4 Cost-Benefit Analysis

Cost-benefit analysis is performed to verify if a project is viable to invest in. It evaluates economical rentability over time and considers the changes of monetary values. Cost-benefit analysis includes variable and fixed costs of activities as well as profits. The analysis considers initial and future costs and profits (Perman et al. 1996, Buncle et al. 2013).

4. MATERIALS AND METHODS

4.1 Area of study

This project evaluated the cost-benefits of predominant farms types in two milking regions: (1) the intensive specialized highland dairy (IS-HD) and (2) the intensive specialized lowland dairy (IS-LD), following the classification of Vargas *et al.(* 2013). The IS-HD represents a 7.6% of the herds which in general are situated on an altitude above 1600 masl. It has the highest production of solids per ha (Vargas *et al.* 2013). Most of the IS-HD are on andisol soils, because this farm typology is mainly found in the proximity of volcanoes and has an annual rainfall of 2600 mm and an average temperature of 19 ^{o}C (Vargas *et al.* 2013).

The IS-LD comprises a 15.4% of the herds. They have an average temperature of 26 ^{o}C and annual rainfall of more than 4000 mms and are at less than 1000 masl. The IS-LD produced 40% less solids per ha compared to IS-HD, with a similar cow per ha density(Vargas *et al.* 2013). The areas of the farms are shown in Figure 3.

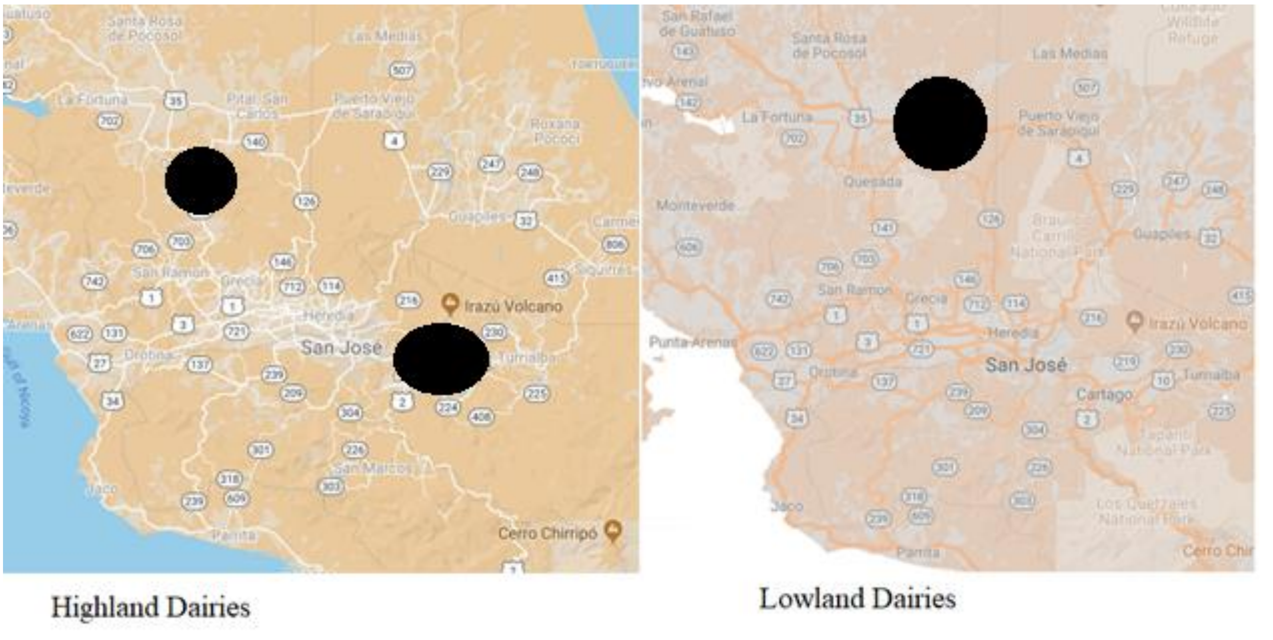

Figure 3. Intensive Specialized Lowland and Highland Dairies Questionnaire locations

4.2 Selection of farms and data collection

We used information provided from a questionnaire by the SusCoRiDa project was used to select the farms. Specific economical and nutrient balance was missing in the SusCoRiDa questionnaire; therefore, an additional questionnaire was developed and applied. With the data from this revised questionnaire, the following data categories for IS-HD and IS-LD was determined: terrain, facility,

diet, production, wages, salary, fertilizer use and herd. This questionnaire consists of 26 farms located in the San Carlos region and 17 farms of Cartago province 43 farms in total.
The information that was investigated in this project can be found in general at the table 2.

Table 2. Information to obtain from the manure questionnaire

Collected data	Units	Aim
TERRAIN		
Size of farm	ha	For the baseline calculation
Average slope	%	For the baseline calculation
Area used for forage grass	ha	For the baseline calculation
Area used for harvesting grass	ha	For the baseline calculation
FACILITY; MACHINERY AND EQUIPMENT		
Livestock hours spent in milking parlor	h	To calculate amount of manures produced in facility
Volume of manures tank	m3	To calculate velocity of manures produced in facility
Frequency and method of application of manures		To calculate amount of manures produced in facility
Water use for cleaning facility	m3	To calculate N concentration
Quickness of fill manures tank	d	To calculate N production
DIET		
Predominant forage grass and legume-grass combinations	dimensionless	To calculate N quantity
Predominant grasses/legumes in stored forages	dimensionless	To calculate N quantity
Concentrate in diet: type and quantity	dimensionless / kg	To calculate N quantity
Nominal percentage protein in concentrate	%/kg	To calculate N quantity
PRODUCTION		
Milk production average	kg/cow	To calculate N quantity
Percentage of milk solids	%/kg	To calculate N quantity
WAGES; SALARY AND FERTILIZER		
Wages and Salaries	Colones	To calculate cost baseline
Fertilizer use		
Fertilizer formula	dimensionless	To calculate savings
Fertilizer quantity	per ha	to calculate savings
HERD		
Size of milking herd	number of cows	To calculate amount of manures produced in facility

4.3 Parameterizing baseline farms in selected milking regions.

A selection criterion was applied to the farms in the SusCoRiDa project, based on the typologies described in Vargas (2013). This criterion selected altitude, size of milking herds and manure storage system. For altitude, the IS-HD farms, the range of 1350 to 1800 masl was chosen; the IS-LD farms were defined to be between 200 and 550 masl. The manure storage system criterion was included to analyze the cost structure of manure usage.

A sample of dairies (n=10) was selected from the SusCoRiDa project questionnaire (n=42). We attempted to use the typologies in (Vargas *et al.* 2013) to select the samples but our attempt failed to reach our minimum of 5 farms. Therefore, we proceeded to broaden the sample through modifying the altitudinal ranges by +/- 100 m. IS-HD (n=5) IS-LD (n=5). The selection criteria is included in the following table. The variable that discriminates both groups is the altitude (Table 3).

Table 3. Criteria in dairy samples, altitude, production, concentrate use, animal density and size by category.

Typology samples	***Altitude masl**	**Milking herd size (Range # of cows)**	**Manure storage system (Y/N)**
IS-LD (n=5)	200-550	50 - 100	Y
IS-HD (n=5)	1350-1800	50 - 100	Y

This table is based on typology data in Vargas *et al.* (2013). IS-LD: Intensive Specialized Lowland Dairy; IS-HD: Intensive Specialized Highland Dairy
*Altitude was modified by +/- 100 m from the original ranges in Vargas *et al.* (2013).

Source: Own elaboration using information from Vargas *et al.* (2013)

4.4 Developing a standard model for manures application

With the farms selected, we average the information collected for each surveyed typology (5 farms for IS-HD and 5 farms for IS-LD). Nitrogen flow and content was estimated by N analysis of purines sampled in each surveyed farm. Table 4 includes information collected for the IS-HD and IS-LD dairy farms. The following data was averaged: farm size, milking herd size, main average slope in farm terrains, area of manures irrigable lands, hours spent by cows in the milking parlor, manures composition.

Table 4. Inputs included for the IS-HD and IS-LD modelling.

N Flow	*Dairy Modeling
Herd size	Farm size (ha)
Pregnancy, %	Nitrogen found in purines (%)
Production, kg	Size of pasture (m2)
Fat in milk, %	Labor invested (h/wk)
Milk protein, %	Altitudinal difference (m)
Milk Urea Nitrogen (MUN) (mg/ml)	Labor cost (Colones)
	Slope (%)
	Confinement time (h)
	Operating time (h)

*Results obtained in N Flow calculations are inputs for the dairy modeling.
Source: Own elaboration the N flow column is based on chapter 10 of (IPCC 2006).

4.5 Analysis and comparison of differences in economic outcomes

To estimate the costs of N, information was collected using secondary sources (SusCoRiDa Questionnaire) and primary sources (structured interview to farmers, structured interview to manure system experts and semi-structured interview to the National Milk Chamber). With the information and data from these sources, a spreadsheet to calculate the CBA was developed.

4.6 Cost benefit analysis of a manure irrigation system

The cost-benefit analysis was for the purine application was based on the direct costs and benefits coming from the system. For example, for the purine irrigation system the following costs were included: reservoir tank, purine pump, pipes and tubes to transport the purines, and cannons at the end of the pipes to spread them. In table 5 a list of costs and benefits of dairy farms is presented.

Table 5. List of costs and benefits of dairy farms in Costa Rica

Costs	Benefits
Feed	Milk
Asset depreciation	Meat
Financial expenses	Calves
Transports	Other

Services
Maintenance
Reproduction and health
Labor
Other

Defining the project and its limits: the temporal limit of the project will be of 5, 10 or 20 years depending on the component and it will have one investment stage. Two scenarios were analyzed: with and without purine irrigation system.

For a projected monetary flow general costs are: Valves, fixed pipe PVC, PVC pipe for mobile irrigation, cannon, plastic tank, hydrants, PVC accessories, Centrifugal pump, cables and electrical accessories, water agitator, miscellaneous materials, wages and salaries of workers installing, operating or making maintenance.

Benefits:

N savings were calculated with the Costar Rican Urea price for systems with and without purine application. The impacts will be classified as benefits or costs depending on their nature. The following is the discount rate selection:

Temporal Horizon	**Discount Rate**
Immediate Future (10 years)	5% and 10%

Calculating NPV, B/C and IRR

Net Present Value (NPV) this calculation was done using the excel financial formula of VNA which is:

$$NPV = -i_0 + \sum_{t=1}^{\eta} \frac{C_t}{(1+k)^t} = -i_0 + \frac{C_1}{(1+k)} + \frac{C_2}{(1+k)^2} + \cdots + \frac{Cn}{(1+k)^\eta}$$

C_t are the net cash flow in each period t

i_0 is the investment done in the initial moment (t=0)

η is the number of time periods

k is the discount rate or of interest required for the investment

Cost Benefit (B/C):

The ratio B/C is obtained by dividing the actual value of the benefits by the actual value of the costs

- If the relation Benefit / Cost > 1 it is accepted
- If the relation Benefit / Cost = 1 it is indifferent
- If the relation Benefit / Cost < 1 it is rejected

5. RESULTS AND DISCUSSION

5.1 Description of the lowland and highland farms

The data from the IS-HD and IS-LD were analyzed and are presented in Table 6. The herds from the IS-HD were numerically bigger than those of the IS-LD. They had a herd of 86 ± 10 head [mean ± 95% Confidence interval (CI)] compared to 72 ± 47 head (mean ± 95% CI) in the lowlands. The mean farm sizes for IS-HD were 22 ± 47 ha (mean ± 95% CI) and 42 ± 47 ha (mean ± 95% CI) for IS-LD, meaning the farms in the IS-HD regions work with more cows per ha according to this study roughly 4 cows/ha in the IS-HD and 2 cows/ha in the IS-LDs. In the altitudinal differences between low points and high points in the farms we had values of 80 ± 56 m (mean ± 95% CI) of difference for the highlands and 46 ± 48 m (mean ± 95% CI) of difference in the IS-LD, these is due to the mountainous and plain terrain of the IS-HD and IS-LD respectively. This might cause greater costs on IS-HD compared with IS-LD, because stronger pumps and more energy might be needed to move purines to pastures due to the greater difference in altitude.

Nitrogen content of purines was greater in the IS-HD compared to the IS-LD. The purines in the IS-HD contained 0.05 ± 0.03 %N (mean ± 95% CI) and in IS-LD contained 0.03 ± 0.01 %N (mean ± 95% CI). Purine N concentrations might differ between IS-HD and IS-LD for different reasons such as: feed protein quantity, amount of water used for cleaning facilities, rain water getting into the purine tank and differences in manure production of the cows. Cows were confined for 6 h/d in the IS-HD and IS-LD. The mean time required to operate the purine machinery, wash the facilities and other purine related tasks was of 10.9 ± 7.8 h/wk (mean ± 95% CI) hours weekly for the IS-HD and 7.9 ± 4 h/wk (mean ± 95% CI) hours weekly for the IS-LD, this difference of work time is due to the higher number of cows and the size of the milking parlor.

Also, data for milk production, total solids, fat, lactose, protein and MUN were collected on each farm. Milk production was 1860 ± 1594 kg/d (mean ± 95% CI) and 1160 ± 612 kg/d (mean ± 95% CI) for IS-HD and IS-LD, respectively. It is important to point out that in the IS-HD the farm that presented the minimum value produced 800 kg/d and the maximum production farm was set at 4000 kg/d; also, the minimum reported value for milk production in the IS-LD is 300 kg/d and the maximum reported value was set at 1500 kg/d. The results from this study showed that milk production by put dairy typology was surpassed by 700 kg/d by the put dairy typology farms.

Total solid production (%) was similar between IS-HD and IS-LD farms 12.9 % ± 0.71 kg (mean ± 95% CI). The fat % mean values were similar in the IS-HD 4.25 % ± 0.52 kg (mean ± 95% CI) and in the IS-LD 4.18 % ± 0.25 kg (mean ± 95% CI). The remaining categories lactose, protein and MUN for the IS-HD were 5.52 %, 3.46 % and 15.34 mg/ml, respectively; for the IS-LD milk lactose content was 5.36 % ± 0.15 kg (mean ± 95% CI), protein content was 3.35 % ± 0.18 kg (mean ± 95% CI) and MUN content was 12.70 mg/ml ± 3 kg (mean ± 95% CI), respectively. Milk urea N was higher in the IS-HD and might be a result of greater protein supplementation.

Table 6. Comparative statistics of the intensive specialized highland and lowland farms

	Highland dairies	Lowland dairies

Category	Mean	95% Confidence interval	Mean	95% Confidence interval
Herd size (cow #)	85.6	75.8 – 95.3	71.6	24 - 118
Farm size (ha)	21.8	-25.1 – 68.7	42.0	12.4 – 71.4
Altitudinal difference (m)	80	24.4 – 135.5	46	-2.3 – 94.3
Nitrogen %	0.05	0.02 – 0.07	0.03	0.01 – 0.04
Confinement time (h)	5.7	1.8 – 9.5	6.0	3.5 – 8.4
Operating time purines (h/wk)	10.9	3.1 – 18.6	7.9	3.6 – 12.1
Milk production (kg/d)	1860	266 - 3453	1160	547.9 - 1772
Total solids %	12.9	12.1 – 13.5	12.9	12.2 – 13.4
Fat %	4.3	3.7 – 4.7	4.2	3.9 – 4.4
Lactose %	5.5	5.3 – 5.6	5.4	5.2 – 5.5
Protein %	3.5	3.1 – 3.7	3.4	3.1 – 3.5
MUN (mg/ml)	15.3	10.3 – 20.3	12.7	10 – 15.3

The 95% CI are overlapping for everything so statistically there is no differences and future analysis would need more data because of the variability associated with the typologies.

We hypothesized fertilizer use would decrease with the implementation of purine systems. However, according to our interviews the majority of farms applied the same amount of fertilizer after the purine system was installed as before. The results from the interviews showed that in the IS-HD 100 % (5 out of 5 farms) of the farms had no change in fertilizer use after purine installment (Figure 4). In the IS-LD 80% (4 out of 5) farms said they used the same amount of fertilizer in the fields before and after the purine system was set to function, whilst 20 % (one farm) said that they apply more fertilizer since the implementation of the purine system and the remaining 20 % (one farm) reported that they had never used fertilizer. See figure 4 and 5 for a graphic representation of the above said (Figure 5).

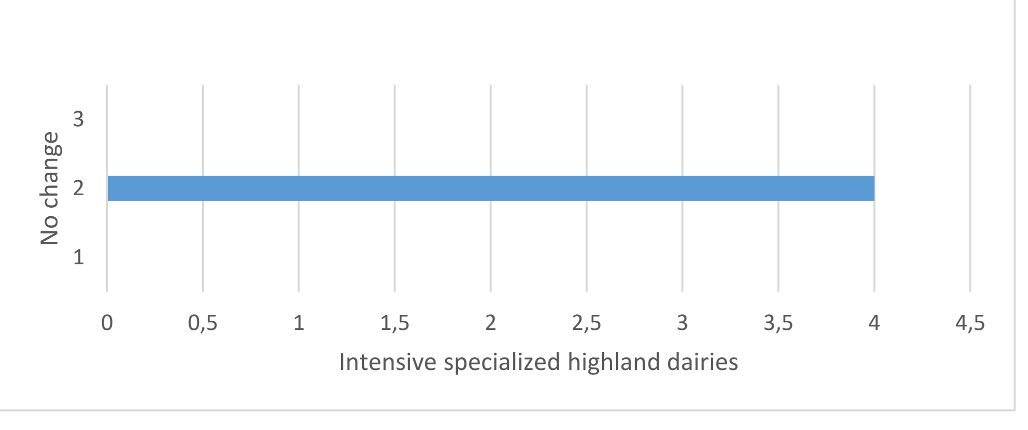

Figure 4. Fertilizer use change before and after purine system installment for intensive specialized highland dairies

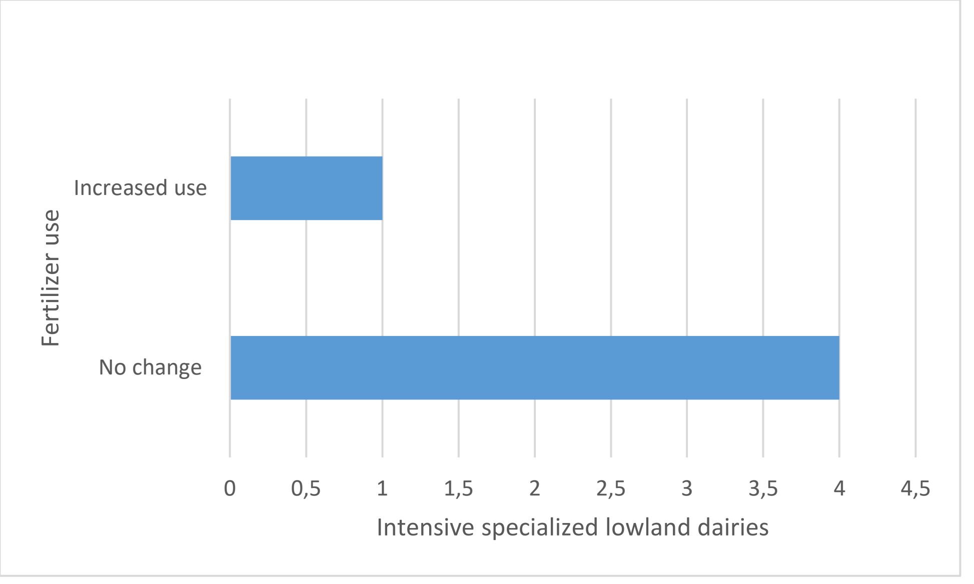

Figure 5. Fertilizer use change before and after purine system installment for intensive specialized lowland dairies

5.2 Farm models in relation to the application of purines to the fields

All the farms interviewed had different purine systems which responded to their need for disposal of purines. However, all farms followed the same steps to collect and dispose their purines: (1) Dung and urine are then produced at the facilities which is later (2) cleaned and mixed with wash water from the animal housing and milking parlor and (3) stored in purine tanks and after (4) purines are disposed to the fields by the pump (Figure 6).

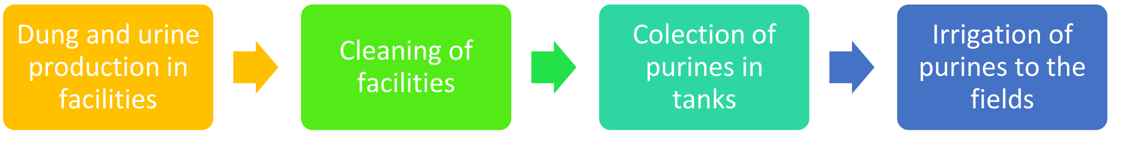

Figure 6. Diagram disposition of purines in the fields

5.3 Cost benefit analysis

The results of the cost benefit analysis that only include the benefit from the added N showed that at a 10 % discount rate and at a 10 year span the benefit cost ratio is 0.24 for IS-HD and 0.15 for the IS-LD (Figure 7), this benefit cost ratio indicator means that for each dollar invested your return for example in this case for the IS-HD for one dollar investment you would get 0.24 dollars in return; this result indicates that if only N is valuated the installation of purine systems is not profitable in either of the analyzed typologies. In addition, the results were calculated at a 5 % discount rate which in turn gave 0.30 for the IS-HD and 0.19 for the IS-LD, the discount rate is basically a rate which is set to compare the actual investment with the banks profit if you just put the money into a savings account, this rate varies according to the type of investment and in this case it was set at 5%. Results showed that even at a lower discount rate the project is not profitable. It is important to have in mind that this study only valuated the N contribution, as mentioned earlier in this text purines have many other benefits like P, dry matter, and microelements, to name a few, if these were to be evaluated in the economic analysis, the results might be more promising, and it would most surely give a better profitability.

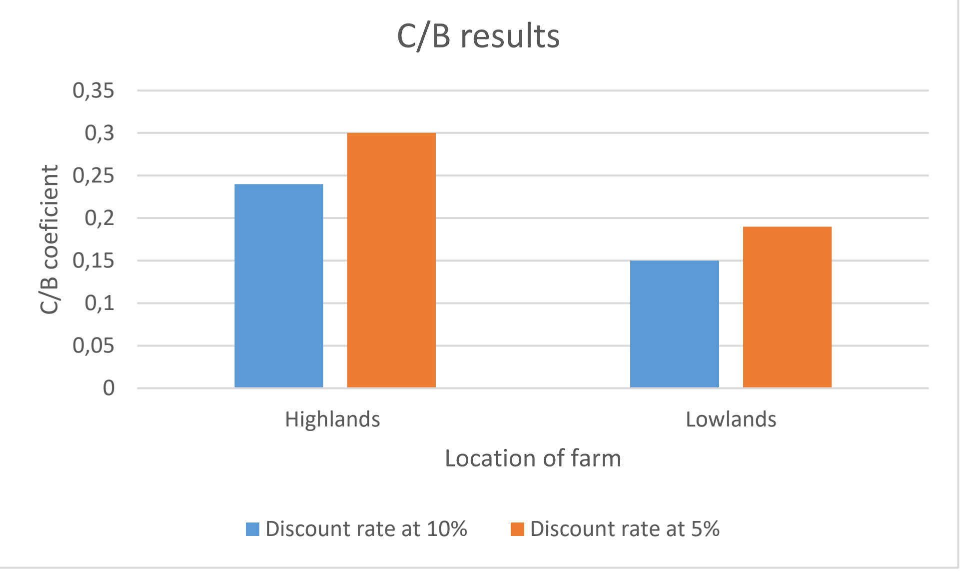

Figure 7. Results from the CBA analysis in the highland and lowland

Figure 8 shows a CBA of a hypothetical farm producing purines with a higher nutrient composition as reported for Chilean farms. In a manual by (Salazar Sperberg y Agr 2010) values for N were reported at 1.28 %, with this higher N values the cost benefit results were: for IS-HD a value of 5.13 B/C which means that for each dollar invested in the system would result in a return of 5.13 dollars; for IS-LD dairy B/C value was set at 4.33 meaning that for each dollar invested it would result in a return of 4.33 dollars. These comparative values demonstrate that if purines were more N rich, profitability could easily be attained. This N richness could potentially be attained by using less water in the daily cleaning or just by covering the purine tank. Also, it is important to know that N was chosen to be the referent value because its higher value in the market, phosphorus and microelements could be also valuated to give a more complete analysis.

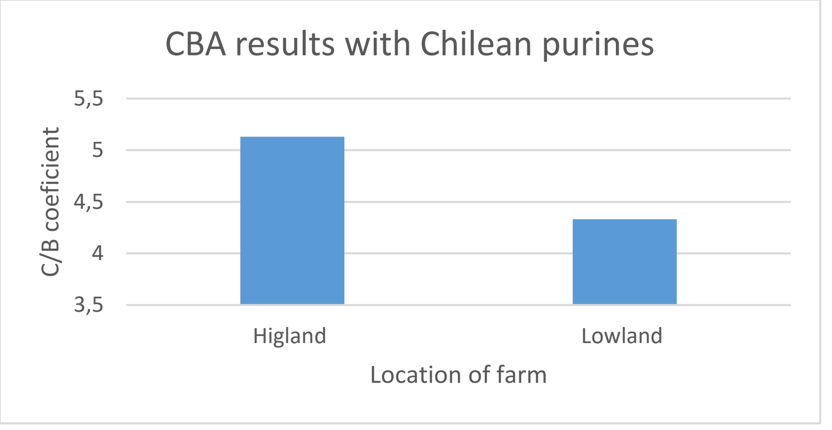

Figure 8. Results from the CBA analysis in the highland and lowland

According to the Costa Rican regulations for the irrigation and use of purines this liquid is considered a by-product which contain nutrients minerals and organic matter, also is said in the regulation that they can be of great benefit for soils and the recycling of nutrients (SENASA 2010). It is also pointed out that the miss use of this by-product can cause grave harm to the environment, putting at risk the health of both animals and human beings, this especially through contamination of water bodies (SENASA 2010). It is therefore recommended that some sort of treatment is done to purines to prevent contamination.

Also a recommendation of trying that your purine is concentrated which means with the least water possible is encouraged. This is because if purine is not concentrated enough transportation costs can escalade, and the farmer could be investing money to irrigate a liquid that has little or no value other than water. It is important to consider also to install closed or roofed tanks that way avoiding rainfall to dilute the purines.

6. CONCLUSIONS

In the first objective we found that the farms in the IS-HD were approximately 20 ha, while the farms of the IS-LD were approximately 40 ha. The highland farms in this study produced 85.3 kg/d/ha compared to 27.6 kg/d/ha produced in the lowlands. The production average per cow was for the IS-HD 22 kg/d of milk and for the IS-LD was 16 kg/d of milk.

For the second objective the modelling part we found out that the ranges of altitude we were basing were too limited, therefore we amplified this range to have more samples to average. Ten farms were used for this purpose which were 5 for IS-HD and 5 for IS-LD. However, all farms followed the same steps to collect and dispose the purines: (1) Dung and urine are then produced at the facilities which is later (2) Cleaned and mixed with wash water from the animal housing and milking parlor and (3) stored in purine tanks and after (4) purines are irrigated to the fields by the pump.

Finally, for the last objective we found that the studied purine system is not economically viable. This is probably because we just analyzed the N content in the purines and we did not take into account other microelements and the improvement of soil organic matter, which is important to consider in further work on this subject. Also we found that the concentration of N in Costa Rican purines is very low in comparison to other countries making it very hard to make economically feasible. Even if this is true regulations in this country support the use of purines to reduce environmental damage.

7. ANNEXES

7.1 Annex 1

Cliente:	ALEJANDRO CHAVARRIA	**Tiempo de Entrega:**	
Teléfono:		**Forma de Pago:**	Contado
Atención:			
Asesor:	ALFARO GONZALES, SENEY	**Validez de Oferta:**	19/11/2019

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
1	18464	334	P.V.C. TUBO SDR-32.5 125 PSI 100MM 4 2025981	COL 28,544.00	0.00	13	COL 9,533,696.00
2	1311	10	P.V.C. TUBO SDR-41 SANIT.100MM 4 2005600	COL 23,064.76	0.00	13	COL 230,647.60
3	23839	4	POLYDUCTO MANGUERA 50MM 2 (45MTS)	COL 84,357.00	0.00	13	COL 337,428.00
4	26716	16	POLYDUCTO ACCES.ADAPTADOR MACHO 50MM 2 602	COL 849.30	0.00	13	COL 13,588.80
5	22712	12	ACOPLE RAPIDO ALUM.2 T/D (HEMBRA RAP)HEMBRA ROSCA 05723200 NPTF 2-D	COL 6,972.48	0.00	13	COL 83,669.76
6	26690	12	ACOPLE RAPIDO ALUM.2 T/A (MACHO RAP) ROSCA HEMBRA 05720200 NPTF 2-A	COL 3,289.02	0.00	13	COL 39,468.24
7	9675	4	P.V.C. TUBO SDR-17 250 PSI 050MM 2 2011649	COL 16,081.88	0.00	13	COL 64,327.52
8	19193	2	RIEGO ASPERSOR 901E 1 1/2 P/BOÑIGA ME33006	COL 212,592.90	0.00	13	COL 425,185.80
9	22912	2	RIEGO BASE SOPORTE P/CAÑON (tripode)	COL 61,609.28	0.00	13	COL 123,218.56
10	26731	2	POLYDUCTO ACCES.REDUCCION HEMBRA 050X38MM 2 A 1 1/2 62550G	COL 841.19	0.00	13	COL 1,682.38
11	19246	50	POLYDUCTO ACCES.ABRAZADERA 100X50MM 4X2	COL 3,725.00	0.00	13	COL 186,250.00
12	34925	50	POLYDUCTO ACCES. VALVULA 50MM	COL 8,777.00	0.00	13	COL 438,850.00
13	26298	50	POLYDUCTO ACCES.NIPLE 050MM 2 607	COL 1,768.00	0.00	13	COL 88,400.00
14	19195	52	ACOPLE RAPIDO ALUM.2 T/F MACHO RAP./ROSCA/MACHO 05725200 (051604)	COL 4,230.00	0.00	13	COL 219,960.00
15	25352	1	THEBE BOMBA ESTAC. 10HP MOD:R-20(R) 1F 220/440	COL 840,000.00	0.00	13	COL 840,000.00
16	34925	1	PANEL DE CONTROL ENSAMBLADO P/ BOMBA DE 10 HP.	COL 725,000.00	0.00	13	COL 725,000.00
17	19190	10	NIBCO LLAVE COMPUERTA 100MM 4 T18-100	COL 142,048.00	0.00	13	COL 1,420,480.00
18	13131	2	LLAVE COMPUERTA NIBCO 050MM 2 125/200PSI TI8-51	COL 28,618.85	0.00	13	COL 57,237.70

1 9	1844 9	20	P.V.C. ADAPTADOR MACHO 100MM 4 2005926	COL 3,864.12	0. 00	1 3	COL 77,282.40
2 0	1810 6	4	P.V.C. ADAPTADOR MACHO 075MM 3 2005924	COL 2,747.00	0. 00	1 3	COL 10,988.00
2 1	2699 2	1	P.V.C. ADAPTADOR MACHO 062MM 2-1/2 2005922	COL 1,625.00	0. 00	1 3	COL 1,625.00
2 2	1808 1	10	P.V.C. ADAPTADOR MACHO 050MM 2 cod 2005920	COL 754.15	0. 00	1 3	COL 7,541.50

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Correo: info@electrobeyco.com Banco BCR: CR25 0152 0121
5000 8148 53
Banco Nacional: CR76 0151 0121 0010 0000 58

Cliente: ALEJANDRO CHAVARRIA

Teléfono:

Asesor: ALFARO GONZALES, SENEY

Tiempo de Entrega:

Contado

Validez de Oferta: 19/11/2019

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
23	19197	8	P.V.C. ADAPTADOR HEMBRA 100MM 4 2012278	COL 7,671.00	0.00	13	COL 61,368.00
24	19209	10	P.V.C. ADAPTADOR HEMBRA 050MM 2 cod 2005906	COL 734.65	0.00	13	COL 7,346.50
25	19198	1	P.V.C. TAPON MACHO C/ROSCA 100MM 4 9004226	COL 6,100.00	0.00	13	COL 6,100.00
26	19204	8	P.V.C. TEE LISA 050MM 2 2005893	COL 1,477.32	0.00	13	COL 11,818.56
27	939	12	P.V.C. PEGAMENTO 950 ML 1/4 GLN 2019790	COL 4,952.89	0.00	13	COL 59,434.68
28	20905	15	CINTA TEFLON 019MM 3/4	COL 955.51	0.00	13	COL 14,332.65
29	19210	6	P.V.C. CODO LISO 90 050MM 2 2005880	COL 1,355.08	0.00	13	COL 8,130.48
30	19219	8	P.V.C. CODO LISO 45 100MM 4 2005936	COL 6,015.00	0.00	13	COL 48,120.00
31	19214	4	P.V.C. CODO LISO 45 050MM 2 2005933	COL 1,149.71	0.00	13	COL 4,598.84
32	28581	4	P.V.C. CODO SANIT. 90 100MM 4 SDR32.5 (P.D.) 2006085	COL 2,619.15	0.00	13	COL 10,476.60
33	28540	1	P.V.C. REDUCCION LISA 100X50MM 4 A 2 2005868	COL 4,452.24	0.00	13	COL 4,452.24
34	28613	1	P.V.C. REDUCCION LISA 050X25MM 2 A 1 9026088	COL 1,031.18	0.00	13	COL 1,031.18
35	39673	1	P.V.C. REDUCCION LISA 100X065MM 4 A 2-1/2	COL 4,496.00	0.00	13	COL 4,496.00
36	25823	1	P.V.C. REDUCCION LISA 100X75MM 4 A 3 2005870	COL 5,148.00	0.00	13	COL 5,148.00
37	19222	20	PISCINA MANGUERA 050MM 2 P/TINA(FLEXIBLE) (4296) zbl	COL 3,651.01	0.00	13	COL 73,020.20
38	25405	8	PISCINA MANGUERA 025MM 01 P/TINA(FLEXIBLE) (4294) zbl	COL 2,456.00	0.00	13	COL 19,648.00
39	26487	6	PISCINA BOQUILLA RETORNO 3/4 SP1419D (3085)	COL 1,526.78	0.00	13	COL 9,160.68
40	19223	6	PISCINA TOMA P/ASPIRADORA SP1022 (adap p/retorno)cod-3084	COL 2,681.31	0.00	13	COL 16,087.86
41	11491	2	P.V.C. UNION LISA 050MM 2 cod.2005837	COL 708.68	0.00	13	COL 1,417.36
42	19206	2	POLYDUCTO ACCES.CODO 90 050MM 2	COL 2,110.28	0.00	13	COL 4,220.56
43	22614	2	ACOPLE RAPIDO ALUM.2 T/AB(HEMBRA RAP)MACHO ROSCA)05721200	COL 6,388.13	0.00	13	COL 12,776.26

4 4	1990 7	1	SD/CENTRO CARGA 04 ESP.QO148L125G/S superf. 1F,3H,125AMP	COL 37,137.45	0. 00	1 3	COL 37,137.45
4 5	633 9	1	CH/CH260 INTERRUP.TERMOMAG.ENCHUF.2P/60A	COL 14,300.00	0. 00	1 3	COL 14,300.00

Cliente: ALEJANDRO CHAVARRIA

Teléfono:

Asesor: ALFARO GONZALES, SENEY

Tiempo de Entrega:

Contado

Validez de Oferta: 19/11/2019

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
46	37092	50	VIAKON CABLE NEUTRACEN 3X2 AWG (ACSR)	COL 1,250.00	0.00	13	COL 62,500.00
47	8459	3	AT AISLADOR PORCELANA TORN.3 1003	COL 4,486.70	0.00	13	COL 13,460.10
48	37915	2	AT ABRAZADERA AISLADA CON CARRETE 3 31597	COL 3,024.00	0.00	13	COL 6,048.00
49	1815	40	TORNILLO P/ METAL 12X38MM 1-1/2	COL 24.21	0.00	13	COL 968.40
50	7738	40	SPANDER PLASTICO S-08	COL 71.65	0.00	13	COL 2,866.00
51	2213	8	TOPAZ E.M.T. CONECTOR T.S.J. 012MM 1/2 E120	COL 116.57	0.00	13	COL 932.56
52	7547	8	TOPAZ E.M.T. CONECTOR T.S.J. 019MM 3/4 E952	COL 197.37	0.00	13	COL 1,578.96
53	24990	1	VARILLA COOPER WELL USA 1.80MTS 5/8 10 MICRAS	COL 6,068.40	0.00	13	COL 6,068.40
54	5549	1	TOPAZ GAZA P/VARILLA USA COOPER WELL5/8 (412)	COL 858.73	0.00	13	COL 858.73
55	10843	12	AT CONECTOR COMPRE.1 YHO-100 KO-R06 OB44 (6-4-2-//	COL 525.09	0.00	13	COL 6,301.08
56	13055	8	AT REMATE PREFOR.CURVO b---N°4 (naranja)	COL 1,043.77	0.00	13	COL 8,350.16
57	590VD	4	CONDUCEN CABLE THHN 08 VERDE	COL 660.00	0.00	13	COL 2,640.00
58	590NG	6	CONDUCEN CABLE THHN 08 NEGRO	COL 660.00	0.00	13	COL 3,960.00
59	590RJ	6	CONDUCEN CABLE THHN 08 ROJO	COL 660.00	0.00	13	COL 3,960.00
60	590BL	6	CONDUCEN CABLE THHN 08 BLANCO	COL 660.00	0.00	13	COL 3,960.00
61	6774	30	GRAPA P/CEMENTO 08MM (TSJ 2X12/3X14	COL 29.97	0.00	13	COL 899.10
62	3564	1	3M TAPE SUPER 33	COL 2,871.69	0.00	13	COL 2,871.69
63	23326	10	CONDUCEN CABLE TGP 2X14	COL 666.09	0.00	13	COL 6,660.90
64	34088	2	HG. TUBO 075MM 3 (6MTS) S/ROSCA SDR40	COL 70,540.47	0.00	13	COL 141,080.94
65	4887	10	AT CINTA BANDIT 1/2	COL 479.33	0.00	13	COL 4,793.30
66	8300	60	AT HEBILLA P/CINTA BANDIT C254 1/2	COL 128.04	0.00	13	COL 7,682.40

67	16065	30	TOPAZ GAZA PLASTICA P/AMARRA 24" APROXIMADO blanca NT24175	COL 264.74	0.00	13	COL 7,942.20
68	25074	2	PVC CONDUIT tipo A TUBO 012MM 1/2 UL cod.2019562	COL 913.36	0.00	13	COL 1,826.72

Cliente: ALEJANDRO CHAVARRIA

Teléfono:

Asesor: ALFARO GONZALES, SENEY

Tiempo de Entrega:

Contado

Validez de Oferta: 19/11/2019

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
69	25082	4	PVC CONDUIT tipo A UNION 012MM 1/2 cod2025012	COL 78.08	0.00	13	COL 312.32
70	25065	4	PVC CONDUIT tipo A CURVA 012MM 1/2 UL cod.2019660	COL 353.55	0.00	13	COL 1,414.20
71	25059	4	PVC CONDUIT tipo A CONECTOR 012MM 1/2 UL cod.2019648	COL 103.02	0.00	13	COL 412.08
72	5900	1	CILINDRO GAS P/COCINA 190 GRS CAMPINGAZ PROPANO	COL 1,630.91	0.00	13	COL 1,630.91
73	34925	1	MATERIALES VARIOS	COL 75,000.00	0.00	13	COL 75,000.00
74	34926	1	SERVICIO DE TRANSPORTE	COL 120,000.00	0.00	13	COL 120,000.00
75	34939	1	SERVICIO DE MANO DE OBRA	COL 1,888,800.00	0.00	13	COL 1,888,800.00
76	28543	2	P.V.C. REDUCCION SANIT.100X50MM 4 A 2 (P.D) 2006150	COL 1,942.50	0.00	13	COL 3,885.00

Subtotal: COL 17,750,813.

Descuento:

Impuesto: COL 2,233,902.17

Total: COL 19,984,715.68

Electro Beyco, S.A. 400m Norte del Mercado Municipal, Ciudad Quesada, Alajuela, Costa Rica.
Cedula Jurídica: 3-101-038663 Tel: (506) 2460-0775 Fax: (506) 2460-6882
Correo: info@electrobeyco.com Banco BCR: CR25 0152 0121 5000 8148 53
Banco Nacional: CR76 0151 0121 0010 0000 58

7.2 Annex 2

Cliente: ALEJANDRO CHAVARRIA

Teléfono:

Atención:

Asesor: ALFARO GONZALES, SENEY

Tiempo de Entrega:

Forma de Pago: Contado

Validez de Oferta: 19/11/2019

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
1	7706	167	P.V.C. TUBO SDR-32.5 125 PSI 075MM 3 2005507	COL 18,714.70	0.00	13	COL 3,125,354.90
2	1311	10	P.V.C. TUBO SDR-41 SANIT.100MM 4 2005600	COL 23,064.76	0.00	13	COL 230,647.60
3	23839	2	POLYDUCTO MANGUERA 50MM 2 (45MTS)	COL 84,357.00	0.00	13	COL 168,714.00
4	26716	8	POLYDUCTO ACCES.ADAPTADOR MACHO 50MM 2 602	COL 849.30	0.00	13	COL 6,794.40
5	22712	6	ACOPLE RAPIDO ALUM.2 T/D (HEMBRA RAP)HEMBRA ROSCA 05723200 NPTF 2-D	COL 6,972.48	0.00	13	COL 41,834.88
6	26690	6	ACOPLE RAPIDO ALUM.2 T/A (MACHO RAP) ROSCA HEMBRA 05720200 NPTF 2-A	COL 3,289.02	0.00	13	COL 19,734.12
7	9675	4	P.V.C. TUBO SDR-17 250 PSI 050MM 2 2011649	COL 16,081.88	0.00	13	COL 64,327.52
8	19193	1	RIEGO ASPERSOR 901E 1 1/2 P/BOÑIGA ME33006	COL 212,592.90	0.00	13	COL 212,592.90
9	22912	1	RIEGO BASE SOPORTE P/CAÑON (tripode)	COL 61,609.28	0.00	13	COL 61,609.28
10	26731	1	POLYDUCTO ACCES.REDUCCION HEMBRA 050X38MM 2 A 1 1/2 62550G	COL 841.19	0.00	13	COL 841.19
11	22632	25	POLYDUCTO ACCES.ABRAZADERA 090X2 IS10320FON90G	COL 3,725.00	0.00	13	COL 93,125.00
12	34925	25	POLYDUCTO ACCES. VALVULA 50MM	COL 8,777.00	0.00	13	COL 219,425.00
13	26298	25	POLYDUCTO ACCES.NIPLE 050MM 2 607	COL 1,768.00	0.00	13	COL 44,200.00
14	19195	27	ACOPLE RAPIDO ALUM.2 T/F MACHO RAP./ROSCA/MACHO 05725200 (051604)	COL 4,230.00	0.00	13	COL 114,210.00
15	25352	1	THEBE BOMBA ESTAC. 10HP MOD:R-20(R) 1F 220/440	COL 840,000.00	0.00	13	COL 840,000.00
16	34925	1	PANEL DE CONTROL ENSAMBLADO P/ BOMBA DE 10 HP.	COL 725,000.00	0.00	13	COL 725,000.00
17	20872	5	LLAVE COMPUERTA NIBCO 075MM 3 BRONCE TI8-75	COL 83,294.27	0.00	13	COL 416,471.35
18	13131	2	LLAVE COMPUERTA NIBCO 050MM 2 125/200PSI TI8-51	COL 28,618.85	0.00	13	COL 57,237.70
19	18106	12	P.V.C. ADAPTADOR MACHO 075MM 3 2005924	COL 2,967.74	0.00	13	COL 35,612.88
20	18081	14	P.V.C. ADAPTADOR MACHO 050MM 2 cod 2005920	COL 754.15	0.00	13	COL 10,558.10

2 1	681 6	4	P.V.C. ADAPTADOR HEMBRA 075MM 3 2012277	COL 2,928.20	0. 00	1 3	COL 11,712.80
2 2	1920 9	12	P.V.C. ADAPTADOR HEMBRA 050MM 2 cod 2005906	COL 734.65	0. 00	1 3	COL 8,815.80

Cliente: ALEJANDRO CHAVARRIA

Teléfono:

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Tiempo de Entrega:

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Validez de Oferta: 19/11/2019

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
23	28591	4	P.V.C. TAPON MACHO C/ROSCA 075MM 3 9004225	COL 3,679.49	0.00	13	COL 14,717.96
24	19204	12	P.V.C. TEE LISA 050MM 2 2005893	COL 1,477.32	0.00	13	COL 17,727.84
25	939	6	P.V.C. PEGAMENTO 950 ML 1/4 GLN 2019790	COL 4,952.89	0.00	13	COL 29,717.34
26	20905	6	CINTA TEFLON 019MM 3/4	COL 955.51	0.00	13	COL 5,733.06
27	19210	10	P.V.C. CODO LISO 90 050MM 2 2005880	COL 1,355.08	0.00	13	COL 13,550.80
28	8639	6	P.V.C. CODO LISO 45 075MM 3 2005935	COL 4,034.03	0.00	13	COL 24,204.18
29	19214	4	P.V.C. CODO LISO 45 050MM 2 2005933	COL 1,149.71	0.00	13	COL 4,598.84
30	28581	3	P.V.C. CODO SANIT. 90 100MM 4 SDR32.5 (P.D.) 2006085	COL 2,619.15	0.00	13	COL 7,857.45
31	9375	4	P.V.C. REDUCCION LISA 075X50MM 3 A 2 2005866	COL 3,043.58	0.00	13	COL 12,174.32
32	28613	1	P.V.C. REDUCCION LISA 050X25MM 2 A 1 9026088	COL 1,031.18	0.00	13	COL 1,031.18
33	19222	20	PISCINA MANGUERA 050MM 2 P/TINA(FLEXIBLE) (4296) zbl	COL 3,651.01	0.00	13	COL 73,020.20
34	26487	4	PISCINA BOQUILLA RETORNO 3/4 SP1419D (3085)	COL 1,526.78	0.00	13	COL 6,107.12
35	19223	4	PISCINA TOMA P/ASPIRADORA SP1022 (adap p/retorno)cod-3084	COL 2,681.31	0.00	13	COL 10,725.24
36	11491	2	P.V.C. UNION LISA 050MM 2 cod.2005837	COL 708.68	0.00	13	COL 1,417.36
37	19206	1	POLYDUCTO ACCES.CODO 90 050MM 2	COL 2,110.28	0.00	13	COL 2,110.28
38	22614	1	ACOPLE RAPIDO ALUM.2 T/AB(HEMBRA RAP)MACHO ROSCA)05721200	COL 6,388.13	0.00	13	COL 6,388.13
39	19907	1	SD/CENTRO CARGA 04 ESP.QO148L125G/S superf. 1F,3H,125AMP	COL 37,137.45	0.00	13	COL 37,137.45
40	6339	1	CH/CH260 INTERRUP.TERMOMAG.ENCHUF.2P/60A	COL 14,300.00	0.00	13	COL 14,300.00
41	37092	50	VIAKON CABLE NEUTRACEN 3X2 AWG (ACSR)	COL 1,250.00	0.00	13	COL 62,500.00
42	8459	3	AT AISLADOR PORCELANA TORN.3 1003	COL 4,486.70	0.00	13	COL 13,460.10
43	37915	2	AT ABRAZADERA AISLADA CON CARRETE 3 31597	COL 3,024.00	0.00	13	COL 6,048.00

4 4	181 5	40	TORNILLO P/ METAL 12X38MM 1-1/2	COL 24.21	0. 00	1 3	COL 968.40
4 5	773 8	40	SPANDER PLASTICO S-08	COL 71.65	0. 00	1 3	COL 2,866.00

Cliente: ALEJANDRO CHAVARRIA

Teléfono:

Asesor: ALFARO GONZALES, SENEY

Tiempo de Entrega:

Contado

Validez de Oferta: 19/11/2019

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
46	2213	8	TOPAZ E.M.T. CONECTOR T.S.J. 012MM 1/2 E120	COL 116.57	0.00	13	COL 932.56
47	7547	8	TOPAZ E.M.T. CONECTOR T.S.J. 019MM 3/4 E952	COL 197.37	0.00	13	COL 1,578.96
48	24990	1	VARILLA COOPER WELL USA 1.80MTS 5/8 10 MICRAS	COL 6,068.40	0.00	13	COL 6,068.40
49	5549	1	TOPAZ GAZA P/VARILLA USA COOPER WELL5/8 (412)	COL 858.73	0.00	13	COL 858.73
50	10843	12	AT CONECTOR COMPRE.1 YHO-100 KO-R06 OB44 (6-4-2-//	COL 525.09	0.00	13	COL 6,301.08
51	13055	8	AT REMATE PREFOR.CURVO b---N°4 (naranja)	COL 1,043.77	0.00	13	COL 8,350.16
52	590VD	4	CONDUCEN CABLE THHN 08 VERDE	COL 660.00	0.00	13	COL 2,640.00
53	590NG	6	CONDUCEN CABLE THHN 08 NEGRO	COL 660.00	0.00	13	COL 3,960.00
54	590RJ	6	CONDUCEN CABLE THHN 08 ROJO	COL 660.00	0.00	13	COL 3,960.00
55	590BL	6	CONDUCEN CABLE THHN 08 BLANCO	COL 660.00	0.00	13	COL 3,960.00
56	6774	30	GRAPA P/CEMENTO 08MM (TSJ 2X12/3X14	COL 29.97	0.00	13	COL 899.10
57	3564	1	3M TAPE SUPER 33	COL 2,871.69	0.00	13	COL 2,871.69
58	23326	10	CONDUCEN CABLE TGP 2X14	COL 666.09	0.00	13	COL 6,660.90
59	34088	2	HG. TUBO 075MM 3 (6MTS) S/ROSCA SDR40	COL 70,540.47	0.00	13	COL 141,080.94
60	4887	6	AT CINTA BANDIT 1/2	COL 479.33	0.00	13	COL 2,875.98
61	8300	30	AT HEBILLA P/CINTA BANDIT C254 1/2	COL 128.04	0.00	13	COL 3,841.20
62	16065	20	TOPAZ GAZA PLASTICA P/AMARRA 24" APROXIMADO blanca NT24175	COL 264.74	0.00	13	COL 5,294.80
63	34076	1	ROTOPLAS TANQUE P/AGUA 6000 LTS	COL 465,580.00	0.00	13	COL 465,580.00
64	25074	2	PVC CONDUIT tipo A TUBO 012MM 1/2 UL cod.2019562	COL 913.36	0.00	13	COL 1,826.72
65	25082	4	PVC CONDUIT tipo A UNION 012MM 1/2 cod2025012	COL 78.08	0.00	13	COL 312.32
66	25065	4	PVC CONDUIT tipo A CURVA 012MM 1/2 UL cod.2019660	COL 353.55	0.00	13	COL 1,414.20

6 7	250 59	4	PVC CONDUIT tipo A CONECTOR 012MM 1/2 UL cod.2019648	COL 103.02	0. 00	1 3	COL 412.08
6 8	590 0	1	CILINDRO GAS P/COCINA 190 GRS CAMPINGAZ PROPANO	COL 1,630.91	0. 00	1 3	COL 1,630.91

L	Código	Cant.	Descripción	Precio	Desc.	IV	Total
69	34925	1	MATERIALES VARIOS	COL 75,000.00	0.00	13	COL 75,000.00
70	34926	1	SERVICIO DE TRANSPORTE	COL 60,000.00	0.00	13	COL 60,000.00
71	34939	1	SERVICIO DE MANO DE OBRA	COL 1,160,000.00	0.00	13	COL 1,160,000.00
72	15735	2	P.V.C. TUBO SDR-32.5 125 PSI 050MM 2 2005498	COL 9,385.00	0.00	13	COL 18,770.00
73	19214	4	P.V.C. CODO LISO 45 050MM 2 2005933	COL 1,155.00	0.00	13	COL 4,620.00
74	25405	6	PISCINA MANGUERA 025MM 01 P/TINA(FLEXIBLE) (4294) zbl	COL 2,155.00	0.00	13	COL 12,930.00
75	28543	2	P.V.C. REDUCCION SANIT.100X50MM 4 A 2 (P.D) 2006150	COL 1,942.50	0.00	13	COL 3,885.00
76	28544	1	P.V.C. REDUCCION SANIT.100X75MM 4 A 3 (P.G.) 9004322	COL 4,340.70	0.00	13	COL 4,340.70

Subtotal: COL 8,890,037.10

Descuento:

Impuesto: COL 1,106,640.77

Total: COL 9,996,677.87

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