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Professional MBA
Entrepreneurship & Innovation

Feasibility analysis of “biogas for cooking” generation based on human waste aimed to low-income population in Colombia

A Master’s Thesis submitted for the degree of
“Master of Business Administration”

supervised by
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Vienna, 8th of April 2016

Affidavit

I, **Diego Castro Torres**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Feasibility analysis of "biogas for cooking" generation based on human waste aimed to low-income population in Colombia", 67 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and

2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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ABSTRACT

Bioenergy is generated through biofuels. These new ways to generate energy are essential for low carbon alternatives in the future on a global scale. Biogas has enough potential to supply electricity and other forms of energy to the world and are supporting pro-poor populations in developing countries like Latin America. Bioenergy has considerably greenhouse mitigation in long term. Nowadays there are several companies and organizations focused to generate Biogas based on cropping systems and besides animal waste and conversion systems together more than 80% emission reductions compared to conventional energy baseline.

In this context, biofuels has a complexity into social aspects and environmental interactions, also has strong correlation with climate change and land use. In Latin countries the impact could be even bigger due to polarization in politics and lack of basic services as electricity and gas for cooking. Hence, tackling this issue would trigger in health, poverty and biodiversity aspects. As a consequence, many conflicts might be solved, reduced or at least mitigated, fostering collaboration among governmental institutions, private sector and communities. Learning factors how to use resources and being proactive with less do more, additional agricultural aspects would be point it out here. Good governance of land use could lead rural development and contribute as major fact to poverty reduction and creating smart communities, fostering employment generation and making them sustainable.

Within bioenergy definition, there is room for generation of biogas based on human waste a low-use methodology in Latin countries and for delimitation of this document specifically in Colombia. Several applications of fecal waste could bring new ideas on the table in a developing country such as Colombia. The social, economic, environmental and sustainable aspects are key to following suit from develop countries like Germany for generation and commercialization of biogas from human waste.

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LIST OF ABBREVIATIONS

GHG: Greenhouse gas

UPNA: Units of Production Non-Agricultural

UPA: Units of Production agricultural

CSR: Corporate Social Responsibility

BOP: Bottom of the Pyramid

MNCs: Multinational Companies

IBD: Inter-American Bank of Development

UN: United Nations

DANE: Departamento Administrativo Nacional de Estadistica[1]

WB: World Bank

N: Nitrogen

P: Phosphorus

K: Potassium

OPEC: The Organization of the Petroleum Exporting Countries

[1] DANE refers in Spanish to Administrative Statistical National Department in Colombia

1. INTRODUCTION

Humanity along regions needs energy to ensure future generations and now more than ever. Nowadays, there are some innovative ways to generate energy such as wind, thermos, solar etc. and some of them are not affordable for impoverished communities in developing countries. Future energy is focused on being clean, safe, accessible and efficient as possible. The transition process to fossil energies to new sustainable energy systems represents a challenge in our global economy and also rethinking process regarding new models. Renewable energy has a pivotal role to play within this challenge.(Colombo et al., 2013)

Biogas is derived from biomass, which can be deployed as liquid, gas, solid for a wide range of uses. For instance as fertilizer for cropping besides basic uses as gas generation for cooking as well. The usage of these new ways of energy triggers in relevant secondary effects such as greenhouse gas (GHG) mitigation, providing additional benefits for sustainable practices and efficient energy-cycle systems. Those systems could benefit or jeopardize communities, mainly due to social and economic aspects are fully compatible. For instance, high prices for non-affordable communities, dogmas in society that foster non-use, traditional customs among others. Good results depends on technology implemented, location (market size, escalation and pace of implementation) and finally what kind of commercialization of social approach are adopted. All of these include how would be the management of existing land.

The generation process of biogas using human waste which will be developed in the documents is biologically digested. Several research institutions rate this method as one of the cheapest ways to generate energy for power generation and other applications. Additionally, the transformation of pollutant raw material like fecal waste would provide to populations big chances to clean water and sanitization process, triggering in higher indexes of public health, access to basic services. This technology can also generate gas on demand at any time and the excess of that could be release to atmosphere in one of the over-demand case, due to there would be enough source of gas as long as a sufficient supply of human waste stocks is assured.(Masera, 2014)

1.1 Problem of the Master Thesis

Energy drives human progress, and due to this there is a fact that in developing countries there is a lack of access to basic services like electricity or gas for cooking. Therefore, those communities are forced to use in some cases wood or gasoline inside houses for cooking. Hence, combustion of those materials are threating public health in some communities. Family members include at least two kids and parents (4 members). According to Statistics National Administrative Department in Colombia 69.7% of the population live in houses and only 40.4% have access to natural gas (basically for cooking) and 83.4% have access to sewage system, which denotes that population in Colombia lacks of access in high proportions but they are covered somehow by sewage systems. (.[Internet], 2005)

And there is no doubt than nowadays more than ever the world is aware and government and institutions want to ensure that the benefits of modern energy services are accessible and for all. Being characterized as clean, safe and efficient as possible. Those aspects are key to generate sustainable energy in long term. Besides, social aspect such as social integration ad reduction of poverty. Additional social issues such as high unemployment rates, low purchasing power, low expectancy of life rate than urban areas, difficult access to education systems, and additional collateral effects which are triggered by no access to basic services.

Finally, the goal of this thesis is elaborate a research in some key low-income communities in Colombia to evaluate feasibility to generate gas for cooking for them. Analyzing operational, social, and basic functionalities easy to adapt for the culture and socio-economic environment in Colombia.

1.2 Objective of the Master Thesis

The main goal is to elaborate a feasibility analysis for gas generation based on human waste aimed to low-income communities in Colombia. Besides, point out the social impact of these initiatives and if those would be beneficial for them, taking into consideration segmentation of the population in vulnerable zones and where we can meet other conditions like agricultural activities which can be foster and improve better

practices of sustainability in soil. Additional make recommendations about international organizations which might help innovation programs to invest and foster inclusivity in poor communities.

Additional explore the operational phase and see if this project could be applicable for specific zones or it would need to meet additional requirements like environmental aspects and land management. Last but not least some key points about the water usage and how this could impact communities in long term.

1.3 Structure and composition of the Master Thesis

This thesis is divided into nine chapters

- Firstly, the approach to a feasibility analysis, what is? and how would be used to address an innovation project. Highlighting the importance of its use to reduce the uncertainty in an entrepreneur project with a methodology to tackle all the angles of the analysis.
- Secondly, social innovation backbone as literature in this project. Giving the importance of this projects in a developing economy which develops societies in long term bringing wellness and sustainability for next generations besides the good results in water preservation and many other environmental factors.
- Demographic analysis and collection of the data. This chapter will address the potential market, describing social-demographic aspects, distribution of ethnic population in big groups and by age. Besides literacy aspects in groups of them by age, all of this to measure and see the impact of no access of education in young generations. Mainly productive activities non-agricultural into the ethnic group territories are based on transformation of agricultural products, especially activities related to making handcrafts. [2]
- Operational / technical background and customized solutions for installation process of tanks and collection of the waste. Considering also environmental conditions which foster the generation of heat to improve and make the process smarter and cheaper. Review of literature and research about feasibility of the

[2] cf. National Agricultural Census 2014. Units of Production NonAgricultural (UPNA) and Units of Production Agricultural (UPA). Colombian Agricultural Ministry & Statistics National Administrative Department. 2016

process and calculation of required stock material to generate certain volume of gas.

- Social and environmental impact, this chapter will focus to analyze benefits or threats for communities. Emphasizing on generation of employment, improvements in the quality of life, better access to education for young generations, awareness of sustainability among others.
- Potential collaboration from international organizations who support innovations and foster new solutions in transition of traditional fossil energies towards clean ones. Overview about institutions and recent projects supported in developing countries. Besides, investments costs related to a pilot project (based on research and assumptions about possible applicable technology).
- Finally, recommendations and comments about the idea taking into consideration the Colombian market with specific population targets.

2. Feasibility Analysis Background

Feasibility analysis is a pre-startup and strategic planning tool, conducted in the pre-business plan phase of a development. It involves a process of "collecting and analyzing data prior to the new business startup, and then using knowledge thus gained to formulate the business plan itself" (Castrogiovanni, 1996). Besides, it is also consider as business tool for strategic planning, some authors considering its rigidity and suppression of creativity as a negative aspect for idea generation process that planning can produce. (Miller and Cardinal, 1994). Other suitable definition for feasibility analysis is an analytical tool used during a business development process in order to show how a business would operate under a set of assumptions. (Agriculture and Service, 2010)

This method also is characteristic by using combination of economic perspective[3], environmental, operational and social/cultural impact, after setting up goals and defining the criteria that will determine the go or no go of the project and finally the recommendations and other alternatives. The importance of the use of this methodology for an entrepreneurial project is mainly by the level of uncertainty in

[3] In this research project, the economic factor would be addressed under the assumptions and guidance from similar projects in Biogas generation from cropping waste.

users, market and operational side. Under this technical tool, we can reduce uncertainty and evaluate under given assumptions the scenarios of the implementation according to the potential users and target market in Colombia. There are two scenarios where are address on page *46* within chapter Economic Analysis, where is assumed different number of member per family and the structure of the community whether is centralized or decentralized.

Additionally this method offers an overview in detail of all variables that could affect stakeholders and natural resources like government, communities, special interest groups (External NGOs), transportation and tourism agencies and feasibility analysis need to be conducted to in order to determine sustainable viability. (Currie et al., 2009) The result will be an overall assessment of the project as describe below:

Identify economic need

- Leaders and other potential member-users identify the economic need the cooperative might fulfill.
- A steering committee of potential member-users is selected to guide the project.

Deliberate

- Develop an overview of proposed business operations.
- Survey prospective members to determine the potential use of a cooperative.
- ***Conduct a feasibility study.***
    - Economic
    - Market
    - Technical
    - Social and Management
- Develop a business plan.

Implement

- Prepare legal papers and incorporate.
- Elect a board of directors.
- Implement the business plan.
- Conduct a membership drive.
- Acquire capital and develop a loan application package.

Execute

- Hire the manager.
- Acquire facilities.
- Begin operations.

Planning Process [4]

However, despite all this planning process described by authors above. There are some entrepreneur literature which revealed that of 220 "INC 500" business[5] 51% of them did not have a formal business plan when they started the business. On the other hand the 49% who did a business plan, an overwhelming (70%) generated them, for the most part, simply to get external financing, besides those business tend to be more profitable. (Castrogiovanni, 1996)

Next table describes the contributions of planning according to some authors. Basically, they are agreed that planning process within a venture represents a symbolism which is obtain financing and communicate vision about long term plans for the venture. Besides, the learning process where enactive learning occurs when leaders create knowledge out of the experiences, for instance they act first and then discern causal relationships between actions and outcomes.

Table 1. Potential benefits of Pre-Startup planning

	US Small business administration (1981)	*Shuman et al.* (1985)	*Timmons et al.* (1985)	*Hisrich & Peters* (1989)	*Sexton & Bowman-Upton* (1981)
Type of Benefit					
Symbolism (e.g., a written plan is generated because financiers want to see one.)	*Obtain financing *Inform others	*Obtain financing	*Obtain financing	*Obtain financing	*Obtain financing *Communicate Vision
Learning (e.g., the business concept is refined to better match market conditions.)	*Find path to goal attainment *Management development	*Company growth *Enhance market understanding	*Evaluate the opportunity	*Determine the viability of the venture	*Evaluate risks *Understand personal issues
Efficiency (e.g., some operating procedures are developed.)		*Improve time efficiency	*Guide the startup	*Guide subsequent planning activities	

[4] Vital steps, a cooperative feasibility study guide. 2010. pp 2
[5] Relatively small companies but fast-growing. See more: http://www.inc.com/inc5000

Source. Pre-Startup Planning and the Survival of New Small Businesses: Theoretical Linkages.1996

In relation to efficiency, planning processes can enhance the venture in two different ways. Firstly, communication of the plan to members of the new organization resulting in cost savings through coordination.(Castrogiovanni, 1996). Secondly, less time is spent as consequence of planning details that could have been addressed before overhead and other costs could arise.

2.1 Financial Analysis

One of the key aspect of the feasibility analysis is the financial aspect. Here, possible economic outcomes are a prominent part of the whole project and are critical in the overall assessment. (Agriculture and Service, 2010).

Hence this part is important part to do and should be checked carefully with the financial projections. These usually are made for three years and are based on valid and objective assumptions. There are some components of the financial side for instance, capital required, equity options, human capital etc. to take into consideration. Due to the financials are so relevant here, the assumption should be aligned with reality of the situation and should not be overly optimistic or simplistic. In addition, most of these analysis start with a pro-forma statement based on the data collected and assumptions stated for instance, sales projections according population, expenses of the project, and also grants which the project could potentially apply in order to infuse more money from World Bank, Inter-American Bank of Development or UN. This document will include pro-forma statement with five years horizon from a pilot project with a reduced sample of the target population.

2.2 Market Analysis

This essential aspect includes industry background and specifically, basic information about gas supply in no-access spots in Colombia, economic conditions in the industry and implications of entering in renewable energies. It would be good to describe details such as geographic applicability (regional, national, local). Besides, the analysis would include trends in the industry and potential applications. Government regulations and policies within the industry like tax exemptions and benefits to foster clean energies

could bring good image for the company and for external organism who likely support financially the project and additional to advise from similar projects in other parts of the world.

Secondly, other components like market potential for the service of gas supply, markets to be served and their attributes, limitations of entering (commercial barriers). Moreover, chart trends, tables that provided a clear picture of the external environment.(Agriculture and Service, 2010)

2.3 Operational Analysis

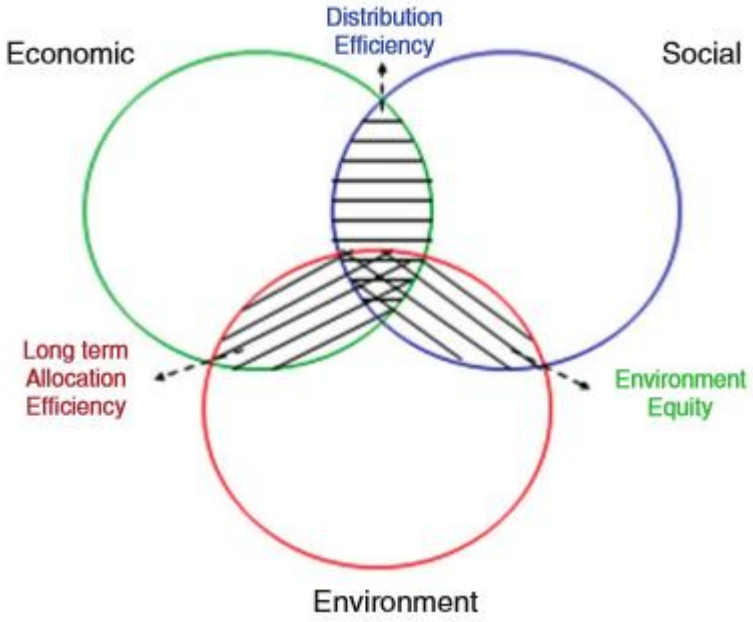
Within the operational characteristics all the feasibility analysis should contain a description of the functionality, including different resources such as, technical labor, supply costs, technical specifications, overall assessment of the potential capacity, locations (including a suitable and right place which could provide external environmental conditions to operate). Furthermore, the description of the raw materials to use and also providing information about how the proposed technology would work in the entire context of the project.

In relation to the potential location, this study should provide the information about labor supply, besides the delivery system proposed and distribution channels. If a location meets with the local regulations or there are aspect to negotiate with local authorities should also addressed how to tackle it.

2.4 Social Analysis

In this aspect there are some cornerstones which are relevant into the analysis, due to the social factors is the core of the project. It gives an opportunity to see the importance of social entrepreneurship in developing countries. This aspect includes, elaboration of a matrix of impact related to potential threats and opportunities with all the stakeholders see more in **Chart 1**. Stakeholder analysis can be used to generate knowledge about the relevant actors so as to understand their behavior, intentions, interrelations, agendas, interests, and the influence or resources they have brought or could bring to bear in decision making process. (Brugha and Varvasovszky, 2000)

Figure 1. Sustainability of interaction of social systems



Source: Cities and Sustainability, Issues and Strategic Pathways. 2015

Coming back about the importance of the application of this methodology to biogas generation project is mainly due to the main elements of the analysis are uncertain. Beginning from the population's conception about the project and their willingness to join until the feasibility in the technical side, besides the qualified labor on site to operate the single or complex facilities which results as an output of this analysis. Due to this statement the importance of the feasibility analysis to uncover this uncertainty into more technical style with a heuristic approach mainly by the innovativeness of the project.

As consequence is mandatory to lay down the participation of the stakeholders in the project and how they would influence the decisions and the path of the communities involved.

2.5 Stakeholders for Feasibility Analysis

Stakeholder theory is a must for feasibility analysis. Basically, the argument is in order to produce equitable and environmentally solutions involving all the key components

of the society who is surrounding the project and could be impacted. Feasibility analysis offers a potential framework for planning and assessing tools to evaluate a proposed project, most of the planners attempt to identify potential stakeholders during the pre-phase of the venture but producing unsatisfactory results. While literature announces stakeholder involvement as a vital aspect of planning. (Currie et al., 2009) Mainly in this case there are several stakeholders involved during the whole process which are mentioned next:

*Government
*Communities
*NGOs and international organisms[6]
*Environment[7]
*Private Sector

Opening the discussion about the involved part in this project. The main character here are communities, in a developing country as Colombia where only 40.4% of the population have access to gas for cooking is an enormous market to tackle besides this country has an expected population in the census 2005 for 2010 around 45,5Mio[8] Those *communities* are representative to be low-income, dependent of one income (head of the house bring the money), average with 2-3 kids in centralized rural areas, difficulties to education access, lack of other basic services like energy and in some zones drinking water, traditional families, hard workers, farmers or artisans who develop any economic activity to raise their families, they cultivate the land and live from tourism depending on the location. Furthermore these communities have hard access to roads, this means transportation systems are not present as basic services and besides the geography of some spots are hard to reach due to mountains and improvised roads.
Despite of the characteristics mentioned above all of them are an overview how would be a generalized opinion for those people who lack access to gas service, however

[6] This term includes Inter-American Bank of Development, World Bank and UN
[7] Within this definition is included agencies who oversee for sustainability in communities and natural resources such as water and land.
[8] See more: https://www.dane.gov.co/files/censos/libroCenso2005nacional.pdf

this aspect to select potential communities and most likely zones would be deeply explore in one of the next chapter in the market feasibility.

On the other hand *Government* , has opened the doors to green energies since a couple of years ago in Colombia, making a new *Law 1715 of 2014* which states that the Colombian Government fosters the exploitation of the non-conventional sources of energy, as well as the promotion of investment, R&D of clean technologies[9]

Under the umbrella of this new law, Colombia is giving steps towards the integration of the green energies to the national energetic system in order to involve private and public sector aimed to exploitation of new sources of energies with clear criteria of sustainability, social and economic factors.

Thirdly, *international organisms* like Inter-American Bank of Development, UN and the World Bank are one of the top institutions with considerable budget to support projects in developing countries. However, in developing countries, protectionist trade and investment policies are often implemented to safeguard indigenous industries from foreigner competition (Luiz, 1997). But in this case the lack of access to basic needs are bigger than we can consider no competition in that field specifically in those remote areas.

The *environment* factor is basically represented by external organisms who protect natural resources as water and soil and they could be a key stakeholders with the communication among communities and an external party who can promote and externalize the impacts in social media and broader spheres.

Finally, *private sector* who could be interested to invest at any stage of the project. Mainly as FDI[10], where this method is conventionally defined as a form of international inter-firm cooperation that involves a significant equity stake in, or effective management control of, foreign enterprises (Luiz, 1997)

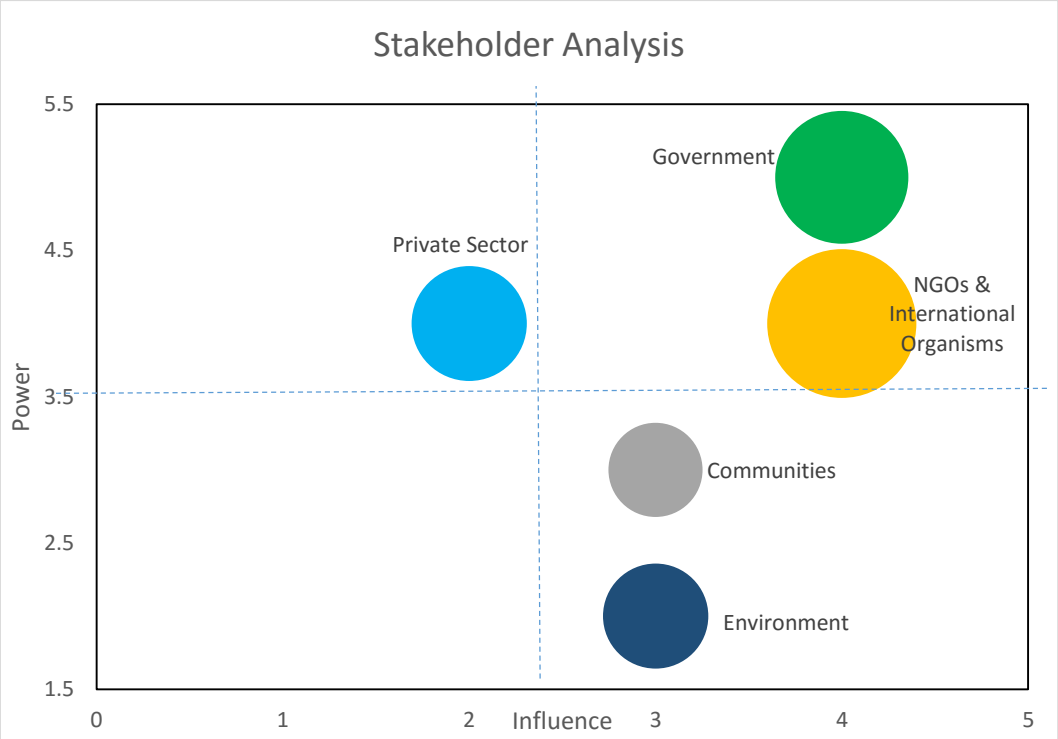
Next table shows the incidence of the stakeholders in this project, where private sector is placed in the upper left quadrant with a relatively low influence in decisions but high power is a group which would require special attention in order to protect their interests. On the other hand Government and NGOs are placed in the upper right corner with considerable influence and high power where a close and good working relationship must be established with them, furthermore, there are communities and

[9] See more: https://www.minambiente.gov.co/index.php/component/content/article?id=669:el-uso-sostenible-de-los-bosques-prioridad-de-minambiente-78

[10] Foreign Direct Investment. See more: http://www.investopedia.com/terms/f/fdi.asp

environment with a high influence and lower power in the right bottom down side of the chart indicating that we have to monitor them frequently due to they could be a source of risks and management should be present every time.

Chart 1. Stakeholder Incidence



Source: Author

3. Social Innovation

This concept has been explored since years ago and nowadays is seen as an astonished term in firms. Some of the current definitions seem to confuse with Corporate Social Responsibility (CSR) but actually this goes further. Current definitions for social innovation focus around new solutions or innovations that somehow are social in their ends or that address societal challenges, in new forms of collaboration. (Osburg, 2013)

The relevance of addressing this term in the thesis is mainly by the core of the idea to generate a service based on raw material which is non-used by communities with low income and who lack of basic service in a developing country. All involvement of

society and other stakeholders make it a huge impact project for pro-poor communities. An impact which could transform communities into regions with a sustainable growth, access to education and investment from different sectors, generating employment and make smarter generations through changeling themselves as society with impairments. Literature mentions that all countries that invest in knowledge are more able to introduce new technological advances and those that innovate have greater labor productivity than those that do not.(Crespi Gustavo, 2012)

Figure 2 Perspectives of Social innovation

Source: Social Innovation: Solutions for a Sustainable Future. 2013

The project to generate gas for cooking for low-income communities has also an ethical side, which encompass the dimension to use an unconventional raw material (human waste) among population with traditional beliefs. However, there are positive outputs like this project likely would increase the shared value for the society to use their skills, resources and local capabilities to lead social progress in ways that even best intentioned government and social sector can rarely match. During this process, the project could earn the respect of the society. (Osburg, 2013)

Furthermore, the chance to add more value to society mainly by combating real problems by those communities due to scarcity of services would trigger curiosity and new solutions to similar related problems like water usage or electricity generation. Simultaneously creating bridges and expanding connections between economic and societal progress.

Humanitarian perspective, this dimension basically encompass the importance of the development within a specific social phenomenon. Encompassing reduction of

poverty, mitigation of unemployment and disparities in general. Also, tackling issues like inequality, urbanization, agricultural transformation, education, health system even corruption. Within the scope of the project as is mentioned before in **Error! Reference source not found.** where communities have a considerably influence but low power in decisions due to they are minorities with low attention from the government side, however, there is a big hidden potential of improvements in quality of life, access to services and new way of thinking after implementation of this project. *Social Capital*, can be defined as an attribute of individuals and of their relationships that enhance their ability to solve collective-actions problems. (Osburg, 2013)

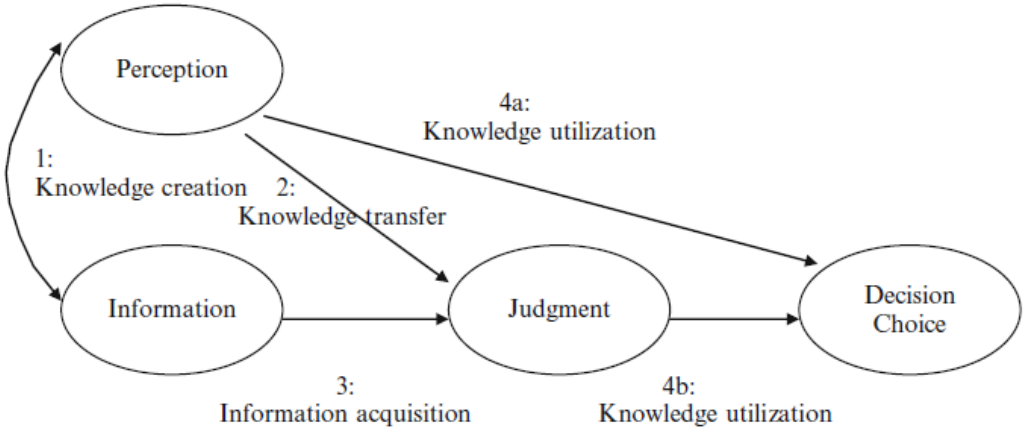
Within this definition we can mention that the project has three essential components in social capital such as: social innovator, which in this case would be the entrepreneur or leaders who change the collectively action situation of a relevant group of people in this case, low-income communities in order to achieve mutual cooperation in the production of public goods. Besides, there are studies where local based initiatives, can galvanize a range of publics to engage them in a wider scope impacting in urban cohesion and social development. (Moulaert et al., 2010). Said this, there are higher chances to engage communities, public sector, NGOs and other external parties in this social problematic.

Replicability of this project would be a major goal after the evaluation of the feasibility mainly by the importance of scalability strategies that could bring new solutions in other areas with different weather or geographic conditions through for instance crowdsourcing.

Knowledge creation see chapter 5.3.1, some leading economies consider knowledge as a driving force of economic growth and at the same time the cause of job creation and other improvements in quality of life. Hence, this became to be more a public policy for governments. In this particular case I would like to use a model to state how would be the knowledge creation during the whole stages of the project as follows.
The two stages for knowledge generation are *perception* and *information,* both are interconnected due to the information can influence how the decision maker frames an optimal solution for the lack of access of gas and in the same way around the information can influence how the decision-maker selects the available information to

be used in the next stages. So, this process is like a dual-process. However, during this another variable play a role due to the difference and, is judgement which clearly depends on the background of the decision-maker and him/her perception. Yet, the decision could be also clear triggering in a decision choice, for instance here I could address the utilization of plastic tanks for storage activities of fecal material or traditional ways to collect those like metal-expensive ones. Along the whole process in every phase there is interaction of knowledge creation, transfer and utilization.

Figure 3 Knowledge-transfer process model



Source: Social Innovation: Solutions for a sustainable future. 2013

On the other hand, it is valid to mention that the competition in those remote areas is practically null but we are considering into pricing strategy the substitute price (Natural Gas) even there is not pipelines service over there, which is taken as reference and potential competitor. Michael Porter may well be right in his contention that the intensification of global competition has made the role of the home nation more important, not less. Particularly, from the standpoint of developing countries, national policies for catching up in technology remain of fundamental importance. (Freeman, 1995)

Next chapter develops and explain how the data was collected and segmented the universe of the population into the potential target.

4. Demographic Analysis and data collection

Firstly, the main source to collect data from the potential consumers is DANE[11], the main institution responsible to collect and carry out statistical analysis of Colombian population, including forecast and projections in most of the aspect of quality of life and economic factors.

Next, a table with the information about the distribution of households along Colombia according to the last census made in 2005. It shows than more than 11Mio of households are placed outside of metropolitan areas where all basic services are offered by public and private suppliers.

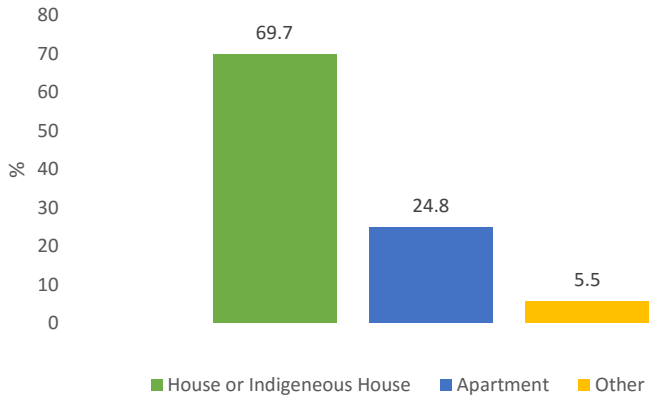
Table 2 Household distribution in Colombia

Área	Households Census	Households Overall	Population 2005	Estimated Population 2010
Metropolitan areas	7,824,702	8,208,838	31,504,022	34,387,230
Country side	2,565,505	2,362,061	9,964,362	11,120,975
Total	*10,390,207*	*10,570,899*	*41,468,384*	*45,508,205*

Source: DANE. Census 2005

The distribution of the households is important to take into consideration the right technical approach in design and functionality, so next chart shows it.

Chart 2. Household distribution in Colombia

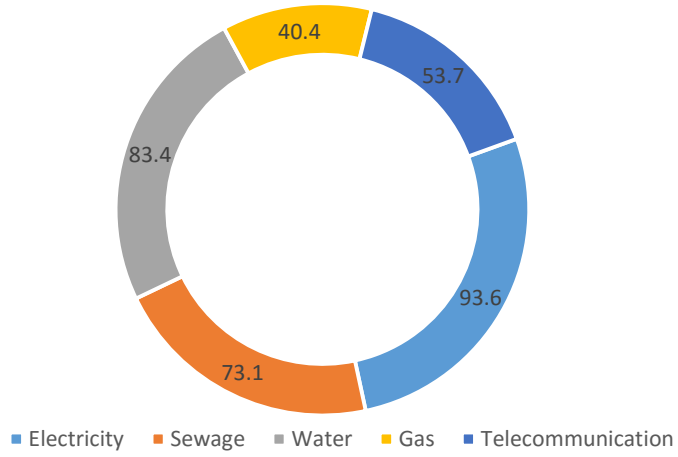


Source: DANE. Census 2005

[11] DANE: Departamento Administrativo Nacional de Estadística. Colombia. See more: http://www.dane.gov.co/

This confirms that the target market is placed in rural areas where only houses are built up. **Chart 3** shows the basic services which are available for the population in Colombia in 2005 being the most updated database to measure this indicator of quality of life but this can point the project out about the lack of it. Basically more than a half of the population does not have access to gas which is considerably high.

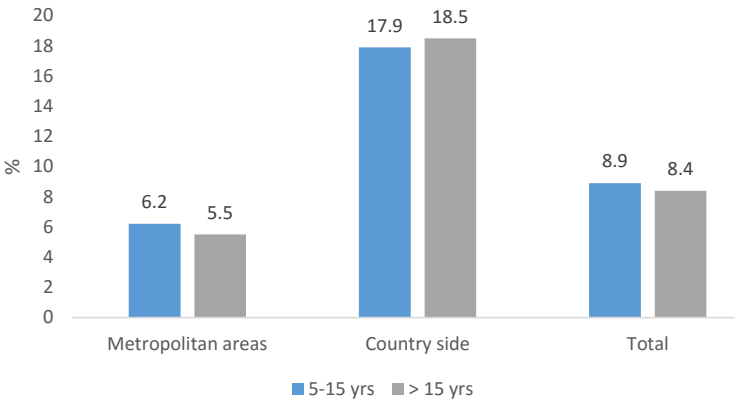
Chart 3. Basic Services in Households



Source: DANE. Census 2005

Chart 4 suggests that in Colombia in 2005 existed a rate of illiteracy above 8% which confirm that those communities presented even a bigger social problematic regarding education due to the population are forced to work since early ages and no infrastructure in educational side are the mainly two factors.

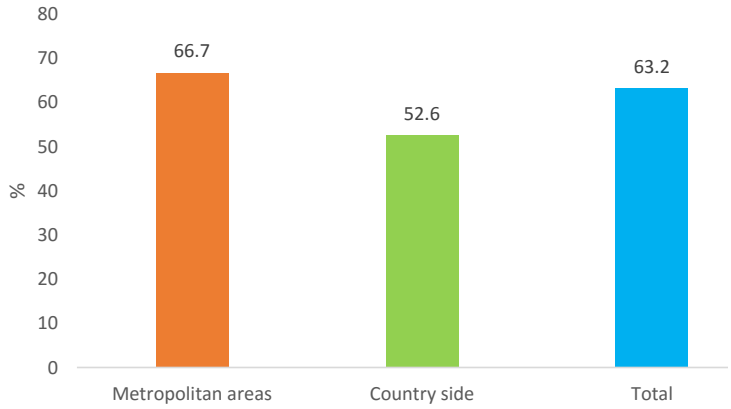
Chart 4. Illiteracy rates In Colombia



Source: DANE. Census 2005

Chart 5. Shows that in the last census in Colombia the attendance rate of Schools were not higher than 64%, this means that a considerably potential students are not attending classes for different reasons, like high distance to go, cultural background from parents who consider education is a luxury service and they should work first, or simply because those towns don't count with schools in rural areas.

Chart 5. Scholar attendance rates in Colombia



Source: DANE. Census 2005

Regarding to the stats from the national statistic department were expected to have 11Mio of population in 2010 and also 40% of them lack of gas service. Under the assumption that have been more than 10 years since that stat, I am going to consider the assumption of reduction of 10 points to 30% of no-gas service. Resulting in 3.3Mio of people with difficulties to cook in households. They use wood or other combustion material causing potential affections to the respiratory system and lower quality of life also triggering in low expectancy of life due to high exposure to those methods even more critical in presence of young people. It affects performance of young generation who attend to schools.

Conclusion: Based on the source of statistical information from National Department in Colombia, it can conclude that the potential market to serve is around 4Mio of people who have no access to gas for cooking in rural areas[12]. Besides all the characteristics

[12] In Chapter 6. Operational Background the target selected is only a pilot project around 380 households

of the target market such as: only 53% approximately of kids can attend to schools, and with illiteracy rates around 18%.

5. Design of the Strategy for BOP[13]

The Bottom of the Pyramid (BOP) is a term referring to the roughly four billion people around the world who live on less than $2/day in purchasing power parity terms and remain largely invisible to Multinational Companies as consumers. (Osburg, 2013)

Figure 4. BOP profitable strategy

Source: Author

As the figure describes to have a successful pro-poor strategy is necessary to meet some premises. Firstly, tools who enable the entrepreneur to alleviate poverty taking into consideration sustainability as direction. Secondly, the innovations related to the project have to serve to those communities more competitive and smart while increase the economic development. Thirdly, engagement is a key point here to involved communities as consumers, promoting the benefits of the change of new ways to cook resulting in better quality of life, build trust, understand the real needs and collaborate with them through NGOs as key partners who count with experience, training in educating people. Finally, the innovation should be relevant a least in a regional scope, the project should be more than local interest in order to raise more government's attention and hence being scalable and replicable to similar cases.

[13] See more: http://lexicon.ft.com/Term?term=bottom-of-the-pyramid-(BOP)

5.1 Engagement Model

There are a couple of ways to engage consumers into this category. First model, consist on design the service for the poor, regarding their needs and adaptable for the specific situation. Particularly in this project to houses in rural areas, most of them with only one floor. Besides, could be an interesting option make a collaboration with NGO like UN or World Bank, assisting in design in similar cases. On the other hand, the project would develop an association with those organizations to train and educate the whole community in different areas like:

Table 3. BOP Model and approaches

Role	Approach
Consumers	Low cost service based on their waste collection, specially design to their needs BOP The innovation process could be leverage and financed with NGOs
Technicians	Local profiles who would be train my local authorities (collaboration and engagement) in safety & environment, technical and maintenance areas
Promoters	Human capital from local communities as well. Hybrid profiles who would be responsible to promote and spread out the benefits about the new service, tackling old and traditions about the use of human waste for gas.

Source: Author

Through easy-communication would face poor potential users to captive their attention in the new service for cooking. Bearing in mind of the advantages in long term about leaving the bad consequences of the traditional methods of cooking with wood which triggers respiratory diseases.

Basically, the same users would be taking responsibilities among the community, fostering the employment and developing local talents who deeply know the real problematic and would be key players during the stabilization process.

Table 4. Approaches to increase access to education in Colombia

Project	Approach	Impact
Gas generation for cooking	*System collection of human waste in low income communities with no access to gas, then storage, generation and commercialization of the service *Create partnerships with local authorities and NGOS to educate parents about the importance to send kids to schools. Educational program. Besides in medium term work with government to raise the number of schools (school per rural area area) and develop a culture of reading.	*Potential market of 4 Mio people. *Average of 176K households with no gas service. *More than 5 regions in Colombia without the service. *More than 625K kids and teenagers between 5 and 14 years old who are not attending schools for several reasons and that number could be reduced significantly if the project tackle internal household issues and sickness caused by respiratoy problems. 2009 figures

Source: Author

These approaches are vastly different but with same goal to engage communities and authorities in the same path. Those provide a variety of ways for the public sector to involve in social problems based on transparency, performance and track during every stage.

Within the scope of this project could be addressed some indigenous communities who live in the Choco area in pacific side. They are still exposed to some customs' outsiders which jeopardize somehow their traditions and even the healthiness, which often enjoy of extremely good conditions. However, this project is addressing something related to access to services in order to improve quality of life and make salubrious spaces to guarantee their existence and mitigate risks. Some argues that tribal peoples –if left alone- are self-sufficient, require no foreign aid. But deprive them of their land, and you deprive them of all the rights, because without the land, they cannot survive.(Clegg, 2016)

5.2 Building the ecosystem

Part of the strategy is already mentioned in the previous titles about communities' involvement approaches and participation of other stakeholders like NGOs and local authorities. However, under this project is relevant consider existing innovations, and understand the aspirations in the BOP can help to accelerate a suitable design and social impact.

Livestock production represents an essential provisioning service in developing countries as is mentioned along the document. It provides not only nutritious food, but many other useful products, especially in rural areas households, such as material for clothes and shelter, energy (biogas), manure, means of transportation, and capital stock in uncertain times (Aerni, 2015)

5.2.1 Existing Innovations

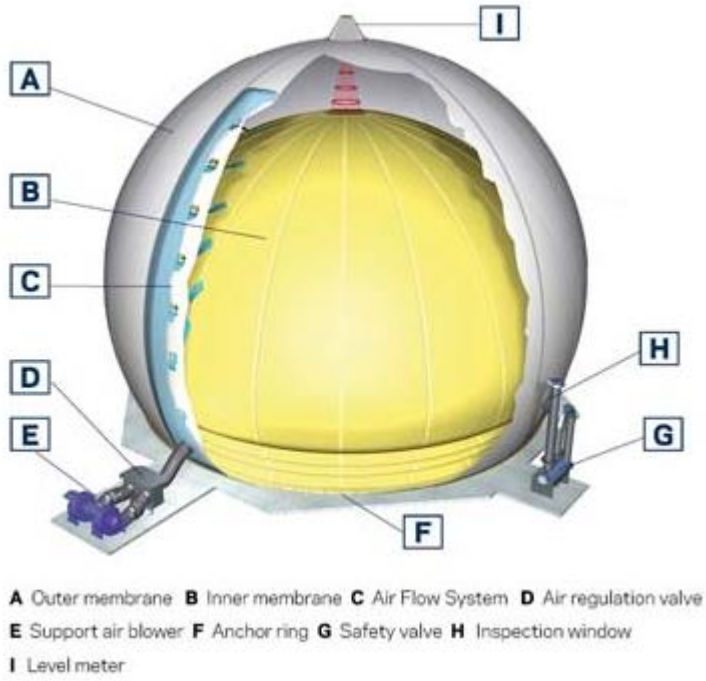
Along Colombia there are several implementations of exploitation of the animal waste in farms. Basically the process is similar, collection of the waste, then storage and production process in tanks and use it for activities in farm like heating system in poultry and also as fertilizer for plantations. Here the optimization of waste is above 80%, however exploitation of human waste is not a pillar yet due to some cultural shocks and association with no-healthy activities. There is a case of a Swedish company Skyllermark who installed their operations in two key regions in Colombia to take advantage of the waste in the north coast of Colombia and in the main city Bogota.[14]

5.2.2 Extend usage scenarios and design regarding BOP conditions

Some of the ideas that surround my mind is using some inflatable textile resistant tanks See **Error! Reference source not found.**.

[14] See more about the news of Skyllermark: http://www.elespectador.com/impreso/negocios/articuloimpreso191654-energia-electrica-limpia-partir-de-basura

Figure 5 Textile storage tanks proposed for gas generation by community



Source: Sattler-Global. Products gas storage DMGS. Internet 2016

Which are made from resistant material to weathertight, and inflates themselves according to the quantity of gas generated (previous calculation of biomass) meeting the safety requirements but less expensive that set up big steel or cement tanks like a factory. Besides, there is the idea of operate a generic plastic tank underneath of the field in every house to collect the waste direct from the sewage system to this collector tank to generate the gas and directly connected to the kitchen or any external device (small plastic bags) to use in the kitchen. These approaches and different scenarios are dependable of the household conditions of each community. At the end any of these ideas could trigger to a common collector area where a big plastic weathertight tank to generate the gas for the entire community and then distributed by bi-weekly small resistant bags for every household, see **Error! Reference source not found.**

Figure 6 Rucksacks for biogas transportation

Source: http://www.bbc.com/news/business-33972995

5.2.3 Relevance for Regional and Global Markets

Here the main implications of a successful design for pro-poor as follows:

a) Flexibility in selection of partners and users. With a tailored design according to their needs there is high likely to be accepted by users and potential to be used further in other applications like electricity generation in a bigger scale and as a natural fertilizer with multiple applications.

b) Low training costs. Easy to use designs enable users to have more adaptability and closeness with the product or service impacting favorably in reduction of costs of training despite the strategy here is to use local people to educate others about the advantages of the service to reduce the cultural resistance.

c) High potential to be used as a hybrid in related projects. As I mentioned before, there is a potential to scale the project to create smart and sustainable communities where all waste can be addressed in only one way, to clean water, fertilize field, increase employment opportunities and develop generations in long term.

d) There are chances to transform the market size, in this case the approach is more social driven to supply gas for pro-poor people, however, there is potential to reach new segments like bigger facilities to generate clean energy and also for water consumption.

5.3 Business implications

5.3.1 Knowledge creation

Companies engaged with the BOP are likely to develop capabilities in several key areas of innovation and design, which may become a source of strategic advantage.(Osburg, 2013)

a) *Usability*: under this cases of BOP this term is well-known due to a high number of users tend to test it. And during this project is relevant to test it but considering at first stages would not be a wide range of tastes or preferences, mainly by it is a generic solution suitable for specific communities but not personalized by user.

b) *Governance:* Develop close approach with NGOs partnerships in order to leverage faster social innovation. Besides, identify interventions that can have positive spillovers effects in other industries will aid growth and benefits along the country even tax exemption according to local regulations.

c) *Faster innovation cycles:* in this project sustainability is a key element and basically the pillar, under the assumptions this project could generate a reactivation of local economies in those communities, also improving access to education and being part of it, in the long term with the collaboration of third parties and local authorities would engaged across regions impacting positively the whole cycle of innovation and understanding inner problems

d) *Multiple usage scenarios:* basically this technology would be tropicalized to local needs and brain power to enable participation of same people around the project, but in future could also scale to urban areas to clean rivers and articulate with a national energy policy related to Greenhouse gas mitigation or even to stages of water filtration of human waste as nowadays United States is leading.

e) *Development of Intellectual Property:* as a spider network, user is part of the innovative process and at the same time user, they become involved with co-creation, the pro-poor people would develop tools to improve the process demanding tailored process and service itself for instance, rucksacks to transport the gas-bags to home if the case is to centralize the gas generation

per community instead of gas generation adapted to every household, under this case the rucksacks for gas can be carry on the back of the user and can walk long distances depending the location of the community. These approaches are dependable of the concentration of people and geographic characteristics also.

f) *Business model design:* if the project requires high investment to work that would translate into high prices for users, so handle this volatility in prices could jeopardize the investment and the access to the service for affected target and certainly pricing is a hot point here due to I have been emphasizing the collaboration with experts and mature organizations leading these problematic across Latin America like IBD, UN or World Bank. It can offer at the early stage of operation flexibility payments.

Last but not least, important part of the strategy with young generations is aimed to reduce the risk of poor performance during growing time. That means work closely with that groups to enable them to be part of the solution educating them in local schools with energy provided with a similar system of collection and bio-generation of gas. Experts say that children from low-income families are at a much higher risk of adverse experiences associated with poor adult health, alcoholism, drug use, depression and poor job performance. (Kaisa, 2016)

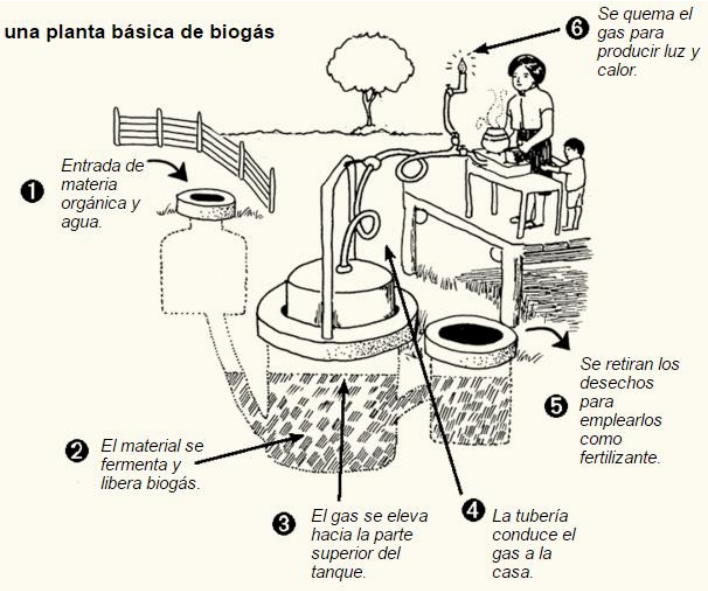
6. Technical & Operational Background

In the 20th century, agriculture was characterized by a long term trend of declining prices. Steady advances in technology led global supply to expand more rapidly than demand, resulting in lower returns per hectare and an increase in farm sizes to allow for acceptable levels of returns, and fueling and exodus from the rural to urban areas. Biofuels present agriculture and rural areas with a long term opportunity in which demand could actually outpace the growth in supply and generate the resources to increase income and capital in rural areas.(Hazell and Pachauri, 2006)

See **Figure 7** where there is an easy-understanding of how works the generation of Biogas based on animal or human waste. Describing point 1. Entrance of the organic

material and water. Point 2 the mixture has a digestion process and release biogas. Point 3 the gas raises upper of the tank or collector. Point 4 the pipeline transport the gas towards the household. Point 5 check and remove the solid waste to use that as fertilizer. Point 6 gas is used to cook and as heating system.

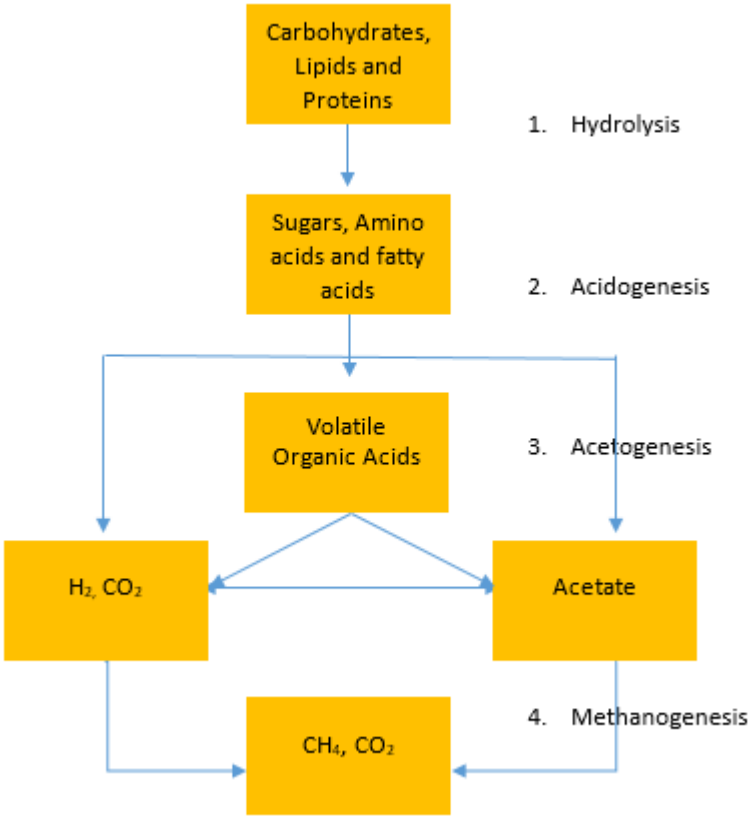
Figure 7. Basic scheme to generate Biogas in a farm



Source: Internet

The most common method to generate biogas is the anaerobic digestion, which is produced in a closed tank called bio-digester. In this case the feces have to be mixed with water in order to get a suspension. This process is made under two main stages. Firstly, through liquefaction process, the organic material placed into the digester is decomposed by enzymatic hydrolysis and fermented in order to produce mainly acids and alcohols. Then, it is the gasification stage where bacteria disintegrate and break chain acids and alcohols to produce methane, carbon dioxide, nitrogen and hydrogen sulfide. See **Diagram 1** to further information about the process.

Diagram 1. Stages of Anaerobic Digestion



Source: Tecnologia del Biogas. Paper. Valle University

The composition of the biogas is approximately 60% of methane and 40% of carbon dioxide. The calorific value of it is 20-30 MJ[15] of caloric energy per cubic meter of gas. Next table displays the composition of the biogas and its participation

[15] It refers to Mega Joule. *Joule: is a derived unit of energy in the International System of Units and represents Kilogram x square meter divided by square second*

Table 5. Biochemical composition of Biogas

Component	Chemical Formula	% Volume
Methane	CH_4	60-70
Carbon Dioxide	CO_2	30-40
Hydrogen	H_2	1.0
Nitrogen	N_2	0.5
Carbon Monoxide	CO	0.1
Oxigen	O_2	0.1
Hydrogen Sulfide	H_2S	0.1

Source: Tecnologia del Biogas. Paper. Valle University

6.1 Operational Parameters

Bacteria and enzymatic processes are led by temperature variation, water level, and general mix composition in the digester. Biogas is only produced under the condition of no-air inside the digester due to this the tank must be hermetic closed.

6.1.1 Water usage in mix

Here there is a procedure to meet in order to provide the correct composition of different materials to maximize the gas generation. Either insufficient water or too much dilution in the mixture make a low-limited gas production. In this particular case, the materials to use would be urine and feces then the comparison rate would be between 1:1 and 1:2. Therefore, every 100kg of human waste should be mixed with 100-200 liters of water. However, if the raw material to use is any cropping waste the proportions would raise to 1:3 and 1:4.(Silva Vinasco, 2002)

6.1.2 Temperature and storage time

Technically speaking, the anaerobic process are characterized by an optimal performance between temperatures among 30-35 Celsius degrees and this is the recommended factor to produce biogas. The temperature always have to be above 20 degrees mainly under this range the generation is ineffective. Taking into

consideration the main regions where the lack of gas access is targeted, are areas with temperatures above 27 degrees due to geographic location. Which is beneficial for the production.

The average storage time for tropical countries like Colombia is around 10-25 days, however if local temperatures are above 30 degrees could be enough 15 days and other colder areas can be around 80-90 days. (Silva Vinasco, 2002)

6.1.3 Acidity and Alkalinity

Bacteria which are present in methane generation are highly sensitive to acidity/alkalinity variations into the digester. Hence, the expert recommendation for an optimal performance should be 6,8 – 7,5 in pH[16]. This quality-performance controls can be easily measured by paper alkalinity test in water. This range is neutral to slightly alkaline.

During the fermentation process are produced high quantity of organic acids which if are not controlled, the mixture could turn into acid one and gradually eroding the bacterial process. Due to this pH regulation is reached by regularly adding alkaline material such as industrial salt.

6.1.4 Nutrients

Nitrogen is mandatory for growth and bacterial activity. Human feces and urine are needed to gas production, it must meet the requirements of temperature and right proportions to optimize the production due to those materials are full of nutrients that can work as fertilizer after the fermentation. Regarding to technical literature is advisable that the carbon/nitrogen proportion is kept at 30:1 or less.

[16] pH is a numeric scale used to specify the acidity or basicity (alkalinity) of an aqueous solution. Solutions with a pH less than 7 are acidic and solutions with a greater pH than 7 are basic.

Table 6. Carbon/Nitrogen Relation of a biogas system

Raw Material	Carbon/Nitrogen Relation
Weath straw	87:1
Rice straw	67:1
Cattle manure	25:1
Human Feces	3:1

Source: Tecnologia del Biogas. Paper. Valle University.

See **Table 7** to observe the range of parameters to make optimal the process of biogas generation.

Table 7. Optimal Range parameters for Biogas generation

Parameter	Optimal Range
Temperature (C)	30-35
pH	6.8 - 7.5
Carbon/Nitrogen relation	20-30
Storage time (days)	10-25*
Water/Solids Relation	6-10

Source: Tecnologia del Biogas. Paper. Valle University. *In tropical countries

6.1.5 Required systems for biogas

I would rather to specify the subsystems which need to be implemented in parallel at first stage as primary subsystems to work properly. As any other company all details such as maintenance, operation, quality and use of the system demands attention all the time to be monitored.

There are some subsystems which implies planning and projection to ensure the work stages properly as follows:

a) Biomass collection: there are two proposals on canvas of collection and this strictly depends on the organization of communities. That organization are meant if the households are close each other like a centralized community or decentralized very dispersed among them. In the first case, those communities could have a central generation base where all sewer system can be ducted in one place and collected in a big plastic digester plus one of the technologies to storage biogas in **Figure 5** and with a pump system to inflate the different

rucksacks of gas according to demand. Those bulks are fully manageable to carry on even by kids and are comfortable for long distances. Furthermore, the collection system is set up by the quantity of waste, characteristics (biodegradability), phases of matter (liquid, solid), collection frequency and transportation towards digester, all of these depend on the success of the system.

See **Table 8** for classification of the different ways which can apply different type of manure to optimize the usage of it.

Table 8. Manure Classification applied to biogas system

Type of Manure	Characteristics
Raw manure	Content of solids of 8-25%, depends on the type of animal, it could be diluted or thickened.
Diluted manure	Content of solids <3%, it is washed with water directly into the digester.
Slurry manure	Content of solids of 3-10% is pumped to the system and storage in digesters, mix with some water.
Semi-solid manure	Content of solids of 10-20% and can be used if that has less than a week, no water requirements
Solid manure	Content of solids >20%. It is not advisable to use for biogas production if it is not fresh or it is dry

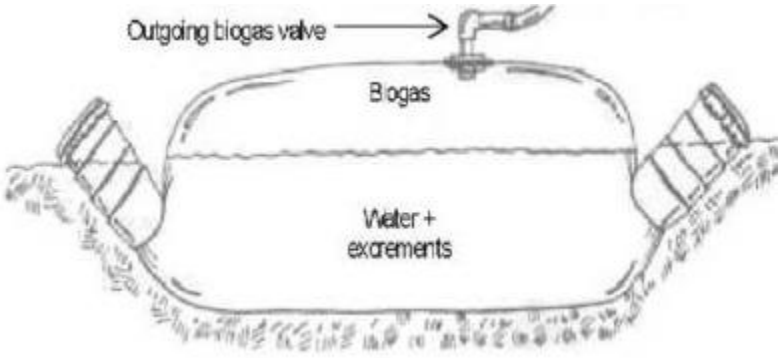
Source: Tecnologia del Biogas. Paper. Valle University.

b) Anaerobic digester: similar to a tank for storage the organic waste could be vertical or horizontal and made with plastic to save costs. Those tanks must be hermetically closed to prevent escape of biogas. The building up cost for an average family is around $80 usd. (Silva Vinasco, 2002)

There are some digesters which are design for families with a size of 6-10m3 and

Produce 1-2m3 of daily biogas from human & animal waste. In most of the used designs, collection process are done by gravity towards the digester in this way the tank should be placed in a lower height of the field in order to make easier the process and reduce the human contact with the waste.

Figure 8. Prototype of digester



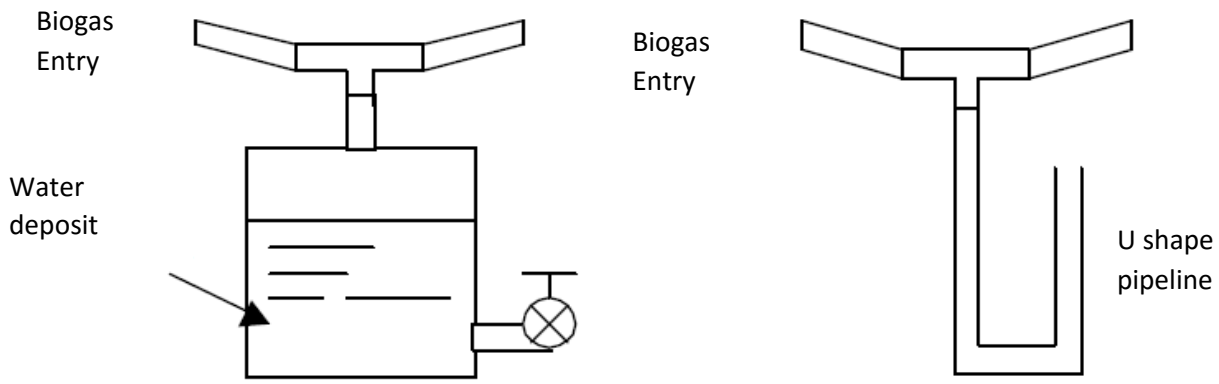
Source: Internet. 2016

c) Storage and handling process: there are two products which are result of the process of biogas generation, first biogas and liquid effluent which is a product resulting from the fermentation and basically is used as fertilizer in plantation. It is highly recommended to make a test to check presence of pathogenic organisms in order to mitigate risks of public health. Moreover, the size of the system depends on the quantity of the fertilizer and this would demand a room for storage aimed for further use or commercialization.

d) Biogas handling: After the fermentation process in 20-30 days after, the system would be ready to use the biogas. Furthermore, the system would be complemented with pipeline system in order to interconnect the source of biogas and households, as well as, pumps, flow meters, pressure systems, drains and removal system of hydrogen sulfide. Safety and public health is relevant due to methane gas is explosive and must be treated like other gases, for that reason must be considered to check periodically the pipelines (could be plastic, steel, copper or rubber). This project would recommend to use copper or some resistant material and reduced long pipeline in order to reduce the pressure drops. Hence,

   that pipeline should has a pump which eliminates the excess of water into the pipelines due to this could cause corrosive acids and jeopardize the system. Next figure describes the pumps

Figure 9. Water removal pipeline option



Source: Tecnologia del Biogas. Paper. Valle University.

e) Biogas applications: as a result in digesters there approximately 60-80% of methane content and its calorific characteristics are around 6kWh/m3 (800 BTU/ft3).(Silva Vinasco, 2002). Resulting in applications like illumination, gas for cooking, heating systems and even in refrigeration processes. There are other applications to make effective the biogas use such as *stoves*. Those are cheap and easy to use, its flexibility, diverse size and low cost are the advantages to use it. Most of the households are used to use two-place stoves and keeping good maintenance of them we can ensure that the efficiency would be high. Secondly, *lighting* is another application and by the way its effect is so positive. However, the stats from Colombia points out that population have access to electricity around 93,6% according to **Chart 3.** This option would fit perfectly for those remotes rural communities which are not interconnected with the electricity network. However, the biogas lamps are not so much efficient, besides got extremely hot resulting in danger for family members and hard maintenance. Thirdly, *refrigerators* which work with ammonia and water. Those equipment can operate with biogas but must require often maintenance from an expert.

6.1.6 Operational considerations for biogas generation

Production rates depend on the type of manure and handling procedures during fermentation in digester. Overall, technically the biogas production is in between 10-30% of the digester's volume per day, besides other conditions like temperature.

Under this approach, it has to take into account that the projections of biogas generation depend on the demand of the users, said this, it deems whether available technology is doable or not. Therefore, what the project expects is supply of this basic need to communities in rural areas, however, under the hypothesis that generation of biogas is higher than the demand of that service[17]

6.1.7 Biogas Demand Estimation

Outset the project established a goal to provide gas for cooking mainly. However there are additional applications which communities could develop in medium and long term in order to improve quality of life and generation of innovation regarding their needs. I am going to use as an example one community in Colombia specifically in Choco region[18] with a number of households in rural area and with no gas access around 38K and located in a region with a tropical local temperature above 27 degrees most of the year. (DANE, 2005)

Feeding habits for those communities are linked to local environment such as plantations or accessible rivers for fishing. But also depends of traditional customs of tribes and social behaviors inherited from previous generations.

Table 9 shows us the average time needed to cook the basic diet for those communities. The normal dietary regime for similar native communities in the Colombian pacific side are based on domestic animals which are represented by: pigs, poultry and fishing. Besides, cooked green plantain, yellow plantain, beans and different recipes with corn. In practice, meat like fish are not so present in those communities' tables due to fishing activities have been reduced in last years.(Rosique et al.)

[17] Here must consider if communities own animals to be taking into account in the calculation of possible raw material to be fermented.

[18] One of the poorest region in Colombia, placed in the pacific coast with tropical weather and good external conditions to generate biogas.

Table 9. Cooking time for foods

Foods/nourishments	Average Cooking time (hr)
Meats	0.5-1.0
Vegetables	0.2-0.4
Cereals	0.4-0.7
Traditional drinks	1.5-2.5

Source: Internet

Additionally the average consumption of some appliances are shown next as reference of demand from households.

Table 10 Biogas average consumption per appliance

Appliance	Biogas Consumption in m3/hr
Stove	0.15-0.20
Stove burners for cooking vegetables & fruits	0.30
Gas Lamp	0.10
Heating system for pigs	0.25
Heating system for hen	0.15
Biogas engine-diesel	0.42
Generation of 1kWh of electricity with mix of biogas-diesel	0.70

Source: Guia para el Consumo consciente, racional y eficiente de la energía. Sector Residencial. 2014

Furthermore, it can be assumed that local people use stoves or more traditional ways like wood or charcoal 4-5 times per day. Considering that traditional ways are not comparable in efficiency as stoves (electric), thus, cooking time with wood takes longer time to get ready food. So we can estimate that families would use 4-5 times per day traditional method resulting more than 5 hours per days being exposed to smoke and low quality air conditions.

Next table shows consumption rates and average cost in Colombia.

Table 11. Typical consumption of electric stove and its monthly cost

Home appliance	Consumption kWh/day	Consumption kWh/month	Cost consumption month (tariff 0.13 usd/ kWh)*
Electric stove two places	5.5	165	21.55
Mix electric stove	2.8	84	10.92

Source: Guia para el Consumo consciente, racional y eficiente de la energía. Sector Residencial. 2014. * exchange rate 1COP 0,00032586 USD

6.1.8 Amount of excreta and urine estimation

According to literature, there is a method to calculate the quantity of biomass required for an optimal production. This method is related to animal manure but still works as reference as follows:

E: Daily Excreta per family

U: Daily Urine per family

M: Total daily average human waste per family

E= specie weight (kg) # of species* Prod. Of excreta per day*

*E = 57 kg * 4 * 1%*

E= 2.28 kg daily per family

U = specie weight (kg) # of species* Prod. Of urine per day*

*U = 57 kg * 4 * 2%*

U = 4.56 kg daily per family[19]

M = E+U

M = 6.84 kg

Amount of excreta can be deemed as % of daily excreta, in humid base or solid state as it shows next table.

[19] Under estimation of density of 1gr/cm3 of urine

Table 12. Excreta Ranges by source

Source	Daily Quantity of		% of fermentation material		Biogas Production m3/ 1kg Organic Solids
	excreta as % of weight	urine as % of weight	% Solids	% Organic Solids	
Bovine	5	4	15.5	13	0.25
Pigs	2	3	16	12	0.35
Goats	3	1.5	30	20	0.2
Horses	5	4	25	15	0.25
Birds	4.5	4.5	25	17	0.4
Humans	1	2	20	15	0.3

Source: Formulacion de un programa basico de normalizacion para aplicaciones de energias alternativas y difusión. Unidad de Planeacion Minero Energetica. 2003

Regarding to DANE, the average number of members in a family in this region are 4 people in 2012 while in the rest of the country are 3.5. (DANE, 2013). Taking into consideration the assumption of 4 member per family, 2 parents and 2 kids, with the following information:

Table 13. Weight estimations of habitants from Choco. Colombia

Family Member	Average Weight (kg)	Excreta kg	Urine Kg*
Father	73	0.73	1.46
Mother	67	0.67	1.34
Kids (each one)	44	0.88	1.76
		2.28	*4.56*

Source: Author * Assumption of density of urine in 1 gr/cm3

Summarizing those weights per family result in 228 kg[20] approximately. Besides the information presented in **Table 12** in order to calculate the daily amount of raw material for digester by 2.28 kg daily per family.

[20] This number considers two kids.

6.2 Estimation of digester's size

Some authors state that the size of the digester (volume) are linked to the retention time (Rt) and the input amount of substrate (S), as the formula points out:

$$V=S * Rt * 1.2$$

$$V= [6.84 \text{ lt} + 6\% \text{ water}] \text{ lt/day} * 37.88 \text{ days}^{21} * 1.2$$

$$V= [6.84+0.41] * 37.88 * 1.2$$

$$V= 329.57 \text{ lt}$$

Formula includes 20% of more volume in order to have room for gas storage.

However, literature indicates that temperature factor matters for fermentation process and the season variations should consider into the planning, however in this case the Choco region in Colombia as tropical area is not affected by considerable temperature variations, only rainy and dry season but keeping average temperature whole year. Additionally the substrate constrain is linked to quantity of water (W) to balance the solid content which is around 4-8% (Silva Vinasco, 2002)

$$S= [E \text{ (excreta)}+U \text{ (Urine)}] + W \text{ (6\%)} \qquad \text{(Lt/day)}$$

6.3 Daily biogas production calculation

Biogas amount daily produced (G) can be estimated by literature and it means the amount of equivalent biogas produced by volatile solid units or humid excreta and percentage of organic material presented on it as well as approximately biogas production. Therefore, calculation proceeds as

$$G= M \text{ (kg)} * \% \text{ of Organic Material} * \text{Estimated biogas production m3/kg}$$

$$G=6.84 * 15\% * 0.3$$

$$G = 0.307 \text{ m3 daily per family}$$

[21] See Calculation of retention rate in 6.4 section

6.4 Retention rate calculation

Size of digester (its volume) is also related to retention rate and by daily load (excreta). As the region is a tropical area with temperatures above 27 Celsius degrees, it results in next formula:

RR: retention rate on days

Ln: natural logarithm

Temp: Average temperature on site where digester will be placed

$$RR=[-51.227 * Ln (Temp)+206.72]$$

$$RR= [-51.227 * Ln(27 \text{ degrees})+206.72]$$

$$RR= 37.88 \text{ days}$$

Table 10 displays that the demand of daily gas is 0.25 m3 per hour and one typical family is producing per day 0.30m3 which is not enough to cover the daily needs in an average family. This is worst scenario where a family uses their excreta plus urine to generate biogas is not enough. However, in a more realistic scenario those families are cohabiting with animals which use to feed themselves and also could be used their waste as raw material to increase the biogas production. That consideration fits in a better way due to the family has to collect their waste and storage that around 38 days to ferment it.

7. Economic Analysis

After operational considerations of the project remains the financial evaluation of the project plus a commercialization. However before this steps, the fundamental principle of crossing the chasm is to target a specific niche market as point of attack and focus all resources on achieving the dominant leadership position in that segment. (Moore, 2002)

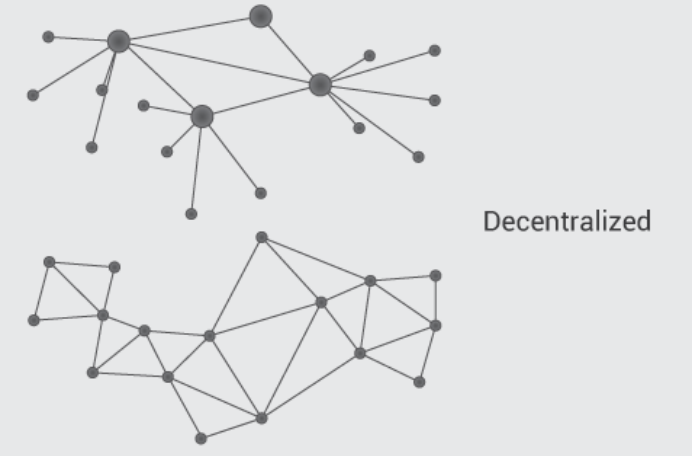
Said this, we know that the target market is poor people from pacific coast in Colombia who are one of the communities in this country with low basic-needs access to public services. It is also pertinent to mention that foreigner investment in those areas is not

common, due to geographic issues like no roads to access, low industrial indicators, and poor participation of educational systems among vulnerable population.

According to **section 6.3** calculation the daily biogas generation per family is around 0.30 m3 and comparing against **Table 10** gas consumption in stove appliance is 0.15-0.20 m3/hr. regarding this is very unlikely that the generation of biogas per household is not meeting the demand per family.

Scenario 1. Decentralized communities. Under this case, where communities are not placed near one from others but long distances are in between, represents a challenge for the gas production. However, in this scenario the project estimate that in Colombia the costs related for setting up a plastic digester of 10m3 is around $275 USD and this includes excavation, raw materials, labor and technical assistance. (Energetica, 2003)

Figure 10. Decentralized communities

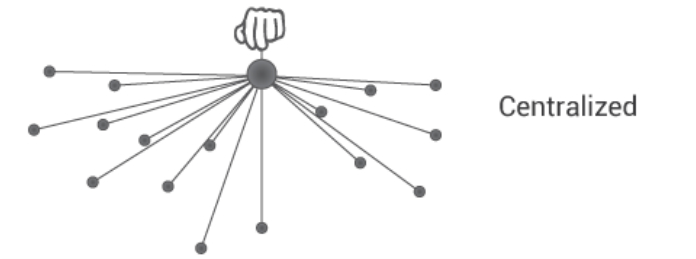


Source: Internet 2016.

However, under the stat of number of members per family results in not enough input for biogas generation. The only condition to install the system would be that each family has around 11 members and at least some farm animals like pigs and poultry which would be so valuable to contribute for gas generation and meet the monthly needs per household. But, remote and decentralized households could be a segment to tackle when the progress of the project is further ahead and not as a primary goal. Furthermore, families would not be agreed to paid for those appliances for home with limited supply biogas generation, but taking into consideration that the demand cannot be higher than the offer or the hipotesis would be reject the project.

Scenario 2. Centralized communities. This case is more doable mainly by the societal factor is key to take advantage of the collaboration among the community and their closeness. For instance these groups are characterized to be placed around a rural area where some progeny rise new families when they reach the aged of adulthood.

Figure 11. Centralized Communities



Source: Internet 2016

Although in those poor-communities is feasible to set up low-cost digester centralized and near to population. Infrastructure could be financed by international organism see more in **section 8.5** and there they could provide the distribution of local biogas to every household by rucksacks for gas.

Table 14. Pro-forma Income Statement Centralized Communities

USD	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**
Revenue	3,876	4,177	4,517	4,902	5,338
Gross Revenue	3,876	4,177	4,517	4,902	5,338
Cost of Organic Matter	388	418	452	490	534
Cost of Water required	8	8	9	10	11
Gross Profit	*3,481*	*3,751*	*4,056*	*4,402*	*4,794*
Operating Expenses					
People expenses	3,600	1,293	1,298	1,302	1,307
Power consumption	360	388	420	455	496
Repairs & Maintenance	100	108	117	126	138
EBITDA	(579)	1,962	2,222	2,518	2,853
Depreciation	1,993	1,993	1,993	1,993	1,993
Net Earnings	(2,572)	(31)	229	525	860

Source: Author

Here some assumptions taken to calculate this scenario:

a) Demand in m3 was taken from **Table 10** the value in between the consumption of gas in stoves. Besides the average time of use per day which is around 5 hours per days.
b) A pilot target was taken to evaluate the income statement projection with a horizon of five years. 1% of the potential population was taken resulting in 380 households as pilot target
c) The estimated production volume per family would be around 1.5m3 daily, under the assumption of minimum 11 family members and farm animals (3 pigs and 5 chickens).
d) For revenues the price per m3 was higher than the cubic meter of natural gas and the figure taken was $0.4 usd /m3 against $0.3 usd /m3
e) There is an assumption of the cost of the organic matter in case the project has to pay for any special collection. 10% of the revenues is the estimation.
f) Cost of the water required to dilute the substrate was taken as 2% of the cost of the organic matter.
g) In the line of operating expenses, there would be 2 persons with a compensation of $300 usd per month and working only 6 months in the installation of the digesters. Additionally the next years, these two workers would be working only in supervising and maintenance of the equipment 2months per year. This includes the estimation of the annual inflation.
h) The line, power consumption is addressed with $30 usd per month in electricity required for pumps in the installation process, also impacted by the inflation rate.
i) The last line of maintenance is expected to be $100 usd in repairs every year besides the inflation impact.
j) Depreciation calculation method is straight line in 15 years.

The next table shows the estimation of investment cost to set up a digester with 60m3 of capacity.

Table 15. Investment of digester equipment and labor costs.

Item	USD
Building materials for biodigester	8,694
Plumbing Materials	1,556
Biogas stoves	6,890
Labour (biogas plants, expansion chambers, canalisation, plumbing, cook stoves installation)	12,756
Engineering planning and supervision	3,900
One year monitoring	2,600

Source: Fonerwa. Biogas technical note. 2015

Conclusion: Definitely those calculations are addressing a pilot project for very small target to measure its profitability, offer and demand calculation per household. Under the scenario of decentralized communities the case is not deeply addressed mainly by the hypothesis should be rejected due to the demand is higher than the offer, however, there are opportunities if those families are bigger than 11 members per house. In this case the opportunity arise and an individual equipment could be installed per home supplying the enough biogas per month with an affordable price of $275 usd (including everything).

8. Social and Environment impact

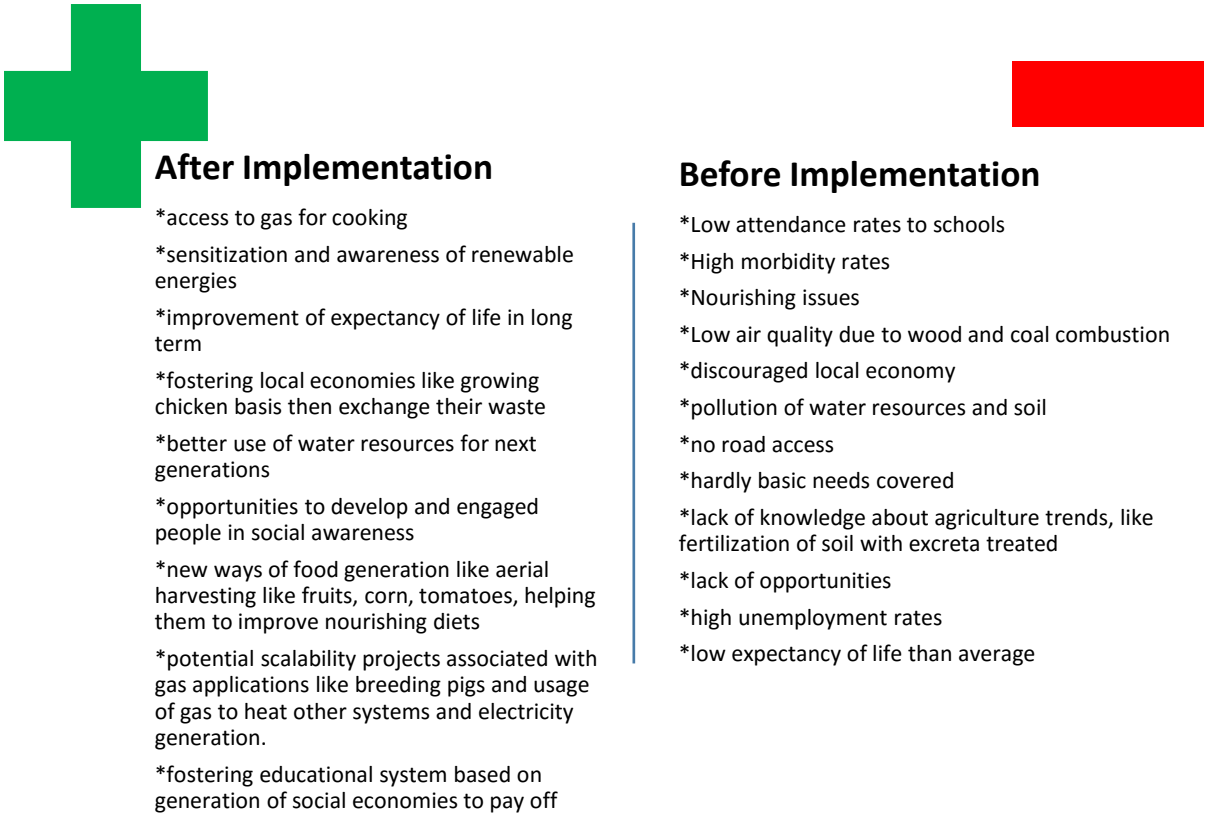
The assumption that ecosystem services can be treated like a commodity that can be bought, sold and traded is built on shaky ground considering the complexity of the underlying social, political and biophysical relationships between humans and the environment. (Van Hecken and Bastiaensen, 2010). And as the author states the social factor here is relevant and most important even than the economic feasibility. Hence, of implementation of a pilot project those communities could leverage on the generation of a basic service, improve the quality of life due to several of them cook inside houses with wood and coal which produces toxic gases against the family integrity. But there are also other hidden factors such as, low attendance rates to school mainly by inability of kids among others.

However, there are other complex implications such as awareness actions in order to educate people to use in the right way the toilets to avoid discarding non-organic material which could jeopardize the fermentation process. Besides, education about the practical advantages of the human waste as green energy and also promoter of GHG mitigation tackling dogmas about the excreta usage.

Bringing development is also one of the key points to those communities. Basically it encompass, reduction of poverty, mitigation of unemployment and inequality. Said this, there will include topics such as: urbanization, the importance of planning communities in a smart way and collaborate them with a common goal like resource development; agricultural transformation, which encompasses the use of new materials like fertilizers that could trigger better results in new food harvesting like aerial harvesting, for instance tomatoes, peppers and other fruits, positively contributing to daily diet; paying relevance attention to basic needs and at the same time improving quality of life.

At the end social innovation is made by humans for humans, but basically is also a tool to give voice to them, social innovation are always based on the voice of the society, communities and people. That is why one of the key aspect to innovate creating a positive impact on society is re-learning to listen to people, listen to their needs, what values are behind, what are their needs, and what they expect for future. Hence, to deem their voice we have to make the right questions in different aspects, like economic, how new ideas could leverage and help communities to raise income or to have a better life; traditions, how strong and compatible are their customs to new ways to do the stuff; and also how ready are them to quit some manners to start to create new paths of development inside their communities. Thus, the next factor is key during the execution of the project and make itself inclusive in people participation. However, there is still the risk of non-acceptance from the community due to dogmas and misconceptions about the practices to generate the source of cooking, even under the consideration of an educational plan with leaders of communities to spread the voice and make the information accessible to all. If those are not ready to accept and adapt technologies and behaviors in order to have prosperity could jeopardize the whole project mainly by no-will the project itself cannot move forward.

Figure 12. Before and after implementation scenario



Source: Author

There are some theories about social literature, where emphasize this projects are made to improve social capital, which allow economic organizations either to function better or to change, thereby producing positive effects on social innovation in profit and non-profit sectors. (Moulaert et al., 2010)

Basically, where there are many actors involved like integration of different economic agendas, with strong ethical norms which include respect for worker's rights and also the compilation of values like justice, co-operation and all of them within the core of the entrepreneur project, which is at the end to serve to unattended needs of a specific sector.

8.1 Education

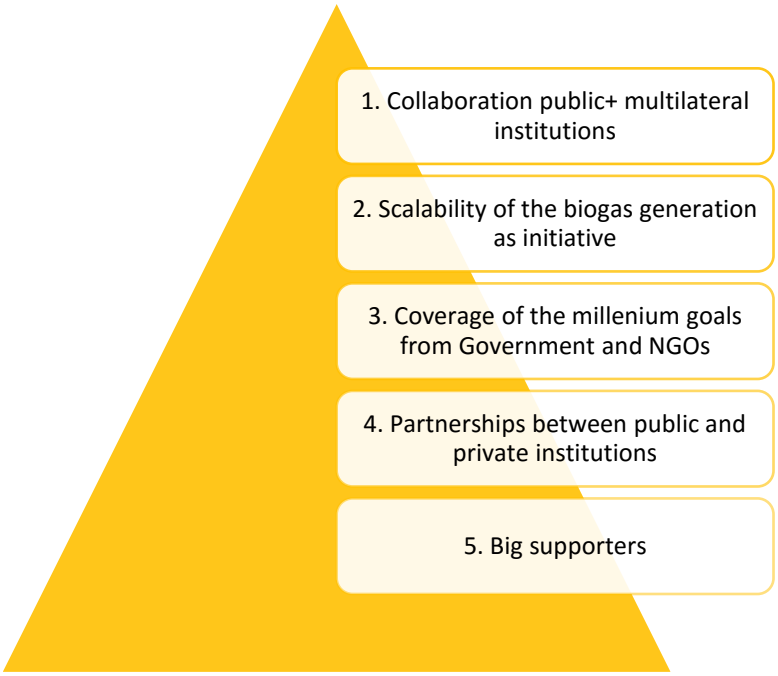
Issues in Education are wide and complex, social and even economic by nature. Business can play a positive role to foster innovation in Education and contribute to better learning. (Osburg, 2013). However, the particularity of those communities are

parents consider children are not in the right scholar age (49%), high educational costs and lack of money (13%), there is no schools near to communities (6%), not enough places for children (5%), had to leave the place of residence (5%), high morbidity rates (4%), lack of interest (3%), children should be responsible for home tasks (2%), among others. (UNESCO, 2012)

Hence, the role of education is so relevant that definitely drives the society growth into a more complex and better interconnected community. In this particular case of pro-poor initiatives for developing countries like Colombia, where government's finances and infrastructure cannot sustain a large scale education system, so the participation and funding from crucial players like UN and WB acting as social innovators and supportive organizations aimed to meet the Declaration of Human Rights by UN.

The structure of the remote operational system could be tackled as follows, however it has to be strongly interconnected with the national Colombian education system.

Figure 13. Pyramidal approach of pro-poor educational strategy



Source: Author

In **Figure 13** displays the *big supporters* as basis of the strategy and basically there are government involvement and NGOs to support education system through initiatives like generation of electricity (when the project can be scalable and

sustainable) in order to supply energy for class-rooms and schools autonomously[22]. With this initiatives from vulnerable communities the chances are higher to be supported from others mainly by goals from local government and multilateral organism is somehow provide attention and being supportive to their basic needs. Those stakeholders are key in previous stages of implementation due to they have the know-how in similar cases but in other geographies which can mitigate errors and bring the project upper with other linked initiatives (deep expertise in agricultural practices).

Follow by *Partnerships between public and private institutions,* it means alliances among them to provide support in areas like training of future teachers. Colombian government has a public organization which is focused to provide remote-education through web platform in several fields like agronomy and technical programs. Additionally, through association with NGOs this project could reach support from private organisms who works with education goal inside the organization and could be supportive with human capital and resources to educate this segment.
Next, addressing the *Coverage of the millennium goals from Government and NGOs* would tackle same goal through collaboration. The new challenges in education overall an even more in remote areas have led to an increase in multi-stakeholder partnerships. (Osburg, 2013).

Said this, this involvement of multi-stakeholders partnerships could become a tremendous innovation factor, why? Mainly by the expertise from government how to address vulnerable population plus the tools and new technologies from NGOs can be easily tropicalized and adapted to their population needs. It calls inclusiveness of the users in the solution of their problems and at the same time the available resources to deliver education.
Furthermore, a collaboration plan with corporate volunteers in Colombia who want to give two helping hands in activities related to education system about the benefits of the transition of usage from wood to biogas. Those activities could leverage on an

[22] This can be an annex project in school under the same model of collection through toilets and educational program of use and take advantage of the traffic of students to generate their own energy, besides, with agricultural lessons in practice where they can leverage on the animal waste contribution to speed up the process.

online hub where employees and retirees can find and add sign up for volunteer projects. That program provides support kits-which include presentations and educational modules in three languages (English, Spanish and Portuguese) for volunteer opportunities in fields with activity-related to agricultural and education topics. (Murray, 2016)

8.2 Fostering local economies

According to Clean Edge research, there is a market growth projection in biofuels which will grow from $20.5 Billion in 2006 to $80.9 Billion by 2016. (Maxwell, 2009)
These group of families are characterized by only one head of the family either father or mother. That person is financially responsible to afford the services and food for their progeny. According to DANE the main economic activities from people from this rural areas (Choco) are mining (more urbanized areas), fishing, agriculture and cattle raising. However, this department in Colombia has one of the lowest progress and development indexes despite its ecological wealth.
After the implementation and the execution of the awareness program to educate users and communities about the relevance of re-use the human waste as source of green energies which could provide some basic needs and help them to rise progress. Collaboration among members of those families would provide right environment for local business, for instance purchasing and sell of animal waste depending on the quantity of resources per family, as well as, generation of new ways to cultivate different aerial products. Trading products and sub-products like fertilizers in one way could activate and engage people to negotiate and trade items than before. Besides, breeding chickens is a smart option to foster development. Those animals could be feed by the waste of the family's kitchen even helping them as a recycling asset, but also they lay eggs and are in constant reproductive stage. It means, different sources of income, through selling them and to feed human being.
Furthermore, there is the chance, under the condition of scalability of the gas generation to collect and produce gas for pig breeding, which is a bit longer but more money involved for them. Additionally, as it was mentioned about new ways of cultivation, one of the ideas is foster aerial plantation with products which rise above the soil and hardly could get in contact with any fertilizer used to improve the quality

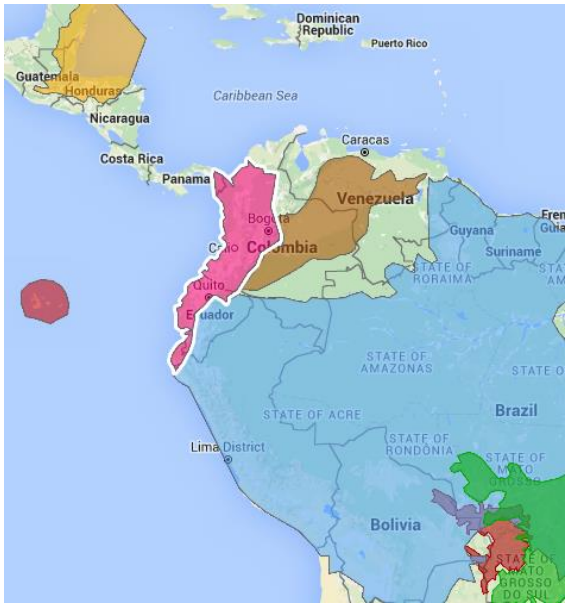
and size of them. This techniques are also very well-known to feed population based on human waste fertilizer as outcome too.

Finally, there are plenty of option could activate and generate local business and bring more progress to those families. Resulting in higher investments on roads and hopefully bringing up roads to access to their communities and trade their products in near locations. It would trigger cells of prosperity and flow of money around them impacting their quality of life and in long term opening eyes in young generations.

8.3 Environmental effect

Choco is located in the pacific coast of Colombia and it represents some of the richest rainforest in Colombia, and also one of the most biodiverse places on the planet. It means it is a region with plenty of water sources and tropical temperatures whole year above 27 Celsius degrees. Those favorable conditions make it one right spot to install the project, moreover the social needs their inhabitants face every single day.

Figure 14. Choco region in Colombia (red highlighted area)



Source: http://wwf.panda.org/what_we_do/where_we_work/choco_darien/

Geographically, **Figure 14** displays Choco region in Colombia, which is a hot tropical rainforest along South America's northwestern Pacific coast to where it connects with Central America.

Mainly by this environmental strategic location is one of the most endanger spots to take care of it. Sources of water are being polluted due to lack of some proper basic services in rural areas. Thus, the implementation of this kind of project could bring safety to drink from water sources and overall wellness to their inhabitants, reflecting in quality of the products in fishing activities, reduction of sickness in children for water contamination, mitigation of E.Coli[23] presence in food and thus low bacterial diseases, improvements along crops related to water usage, among others.

On the other hand soil management is also benefited mainly by use of the fertilizer produced as a second product of the fermentation of the excreta and useful for any crop. However, regarding literature it is impossible to predict the contribution of nutrients in manure will make in the future, but in Latin Countries those industries are still the unique source of Nitrogen (N), Potassium (K) and Phosphorus (P) in comparison with other European countries where they use minerals as an alternative. Nevertheless, there are risks related to the misuse of those components in excess due to accumulation of heavy metals in soil, which in long term would represent jeopardize for public health. (Sheldrick et al., 2003)

Here with this excess product after use in crops the inhabitants of those areas have the opportunity to commercialize it and open a new window of opportunities in revenue generation.

Conclusion: As a result of this innovative process there is a product which can be used as a fertilizer in any crop in vulnerable communities as a source of revenue but also as a raw material for their plantations. The global trend of this product goes down but in developing countries is still one of the most used elements in agriculture and there is plenty of potential for their own use and benefit.

[23] Escherichia Coli (abbreviated as E.Coli) are bacteria found in the environment, food, and intestines of people and animals. They are diverse group of bacteria. Although most strains of them are harmless, others can cause diarrhea, urinary tract infections, respiratory illness and pneumonia.

8.4 Benefits and Risks about the implementation

Medium-term prospects for biofuel overall production remain strong despite the current oil price decline. However, the implications of continued growth in biofuels are less clear. Optimists, such as Ricardo Hausmann [24] foresee a world in which biofuels blunt the monopoly power of OPEC, thus leading to a stabilization of world fuel prices at approximately the marginal cost of biofuel production.(Arndt et al., 2010)

Now, with this trend exposed above there are plenty of opportunities to explore into new energies, however, there are also risks and advantages that should be considered, and it is explained in the next table.

Table 16. Risk and Benefits of implementation

Benefits	Risks
-Environment outcomes in water preservation	-Problems with the intensive use of pesticides and fertilizers, threat local biodiversity
-Mitigation of GHG	-Risk-averse stance from investors and higher up-front costs
-Improvement in waste disposal	-Perception of high-risk leads higher interest rates and higher equity requirements
-Contribution for better enviromental management	-Demand outgrowing supply
-Reduction of nutrient depletion, using organic matter from animals and crops	-Disruption/failures in supply network.
-Overall improvement in quality of life for families, air quality	-Extreme natural events, could triggers into floods that can disrupt the infrastructure
-Fostering local economies and trading	-Enviromental impact and health if raw material is not properly treated
-Likely option to attract investment in region due to access to roads and imminent development	-Sabotage could exist from remain illegal armed groups
-Good scenario for better attendance school rates	
-Better education means prominent future	
-Activation of awareness in innovation and resourcefulness	

Source: Author

[24] Director of the Center for International Development at Harvard University

Despite of several cons after implementation of the project, grouping all of them are not enough to defeat the great benefits to implement[25] it. However, those comparisons with benefits and disadvantages in a developing country shows the importance of the social impact that can engender over next generations. Hence, the virtues can tip the balance in favor. However, it is noted that sustainable habitat has to specifically include suitable access to land tenure, affordable housing, water supply, sanitation, education, health and social security.(Pathak et al., 2015)

And those seems to be a prerequisite in a normal society but in communities where the lack of services are at first hand is not the case. Maximization of land use can leverage on communities as sustainable communities, they would be integrating water preservation without pollutants from excreta, treat their waste as source for food process generation, inclusion of new food to the traditional diet and one of the most relevant is creation of microbusinesses and trading.

On the other hand there is a proposal to integrate those remotes areas (rural zones) to the municipal scope. In that way promote inclusivity habitat with a particular focus on pro-poor communities. Overall this would trigger a mobilization and flow of resources. Firstly, resources assigned by government and resources generated by entrepreneurial communities to bridge with partners (municipalities). Definitely, this cooperation could facilitate the integration of poor or non-existing infrastructure/services.

8.5 Role of NGOs and application

Social capital is increasingly recognized by entrepreneurs of pro-poor projects. And it results in an important support to develop initiatives that could shape a new overview for vulnerable population. As the world's largest intergovernmental organization concerned with poverty alleviation, the World Bank (WB) can be used as a bridge to connect different social groups (investors, government and communities) around one goal and it is overcoming disparities between an urban society where they have access

[25] This statement is made under the conditions of meeting the basic requirements like number of members per family and environment temperatures to avoid heating systems for digester making the whole operation more feasible overall.

almost to everything and from other side a marginalized one. Regarding to some literature, experts advice that the project should enable environments and that means that the scope for effective use and also strengthening of social capital depends critically on the nature of the wider political and policy environment. (Fox and Gershman, 2000)

There are some key points to take into account in order to enable the proper environment to foster social capital. Firstly, integration of communities in design and part of the process, it means low-income population from remote areas, especially native (indigenous) should be consulted and involved in the solution of their problems. Secondly, be sure as entrepreneur about the timetable of the application process in the WB which documents should need to turn in, when, whom, in what language etc., however, WB or other multilateral institution would make the effort to publish and disseminate the basic documents. Finally, as an already design project, entrepreneurs should propose new institutional mechanisms for sharing control between the state and representative of the civil society, in this case a local leader. If so, also the project should list the criteria, besides, a verification model of that person is the right candidate to represent the voice of the rest of community.
It is important consider political investment meanwhile the project is working with social capital (WB) mainly by there is no unidirectional arrow between the design and phases. Biogas generation could work perfectly involving communities and make them participate in the phases but in worst scenario this could not happen and then erode the project. It means the opponents of the project should be checked often due to they are likely to remain entrenched within our own society, so only the way to keep the political capital as allies, in the better understanding as a promoters of the initiative to scale it to certain levels where the project would require exposure to be supported.

9. Recommendations

After whole evaluation described along the chapters and considering some assumptions, the project could be evaluated as:

- Viable project under the recommendation to install the digesters in communities where there are at least 11 members per family in order to get enough excreta

to meet the needs of monthly consumption in decentralized areas. In addition, those families must have poultry and pigs aimed to complement the mix and speed up the gasification process mainly by chemical composition itself.

- Project is also doable in centralized areas where families' size is less than eleven, under the condition of work and collect the human waste along the community as well as the animal waste. Thus, the process of collection is also centralized and the distribution method would be addressed with rucksacks of special material and easy to lift up that even a child is able to carry it on his/her back. The last method would require a considerably higher investment from government and multilateral institutions to operate it but also outsource staff to operate the in-site facility.
- In order to make the project feasible, leaders (entrepreneurs) in this case must involve communities to participate and take over decisions in their own problems. The project can start and being implemented during a couple of years but communities will still be there. So their inclusion is so relevant that the project could lead longer planning time but that would worth it. The possible tension created between their needs (urgency) and patience (planning schedule) would trigger in a productive tension. Thus, that situation would lead the project into the right level of engagement of communities and other stakeholders. A weak civic culture undermines the best intentions and the most rigorous of analysis and plans. For change to happen, trust and community ownership must form, people need to engage with one another, and we need to create the right underlying conditions and capabilities for change to take root and spread. (Barnes, 2016)
- Preservation of natural sources as water and soil management could trigger in better conditions for next generations. Productivity and new forms of traditional farming including aerial farming with new products like tomatoes and beans which could reduce the contact with soil after use of fertilizers, besides the micro-business generated through possible trade of materials in later stages would benefit communities to improve their purchasing power reflecting a better future.
- Methodology of feasibility analysis led levels of uncertainty of the project to clearer stages to measure the project. This methodology addresses through

different chapters of market segmentation until the benefits and social impacts that could triggers the project itself. There were two scenarios where were measured the amount of excreta required to produce the minimum quantity of biogas to meet the demand of households among community. It results in a strong recommendation to go if the production is higher that the demand otherwise the project should be rejected. Due to this the number of members per family should overcome 11 in decentralized areas.

- Potential development projects like light for schools and public places could help communities to integrate a better planning as society. If those are channelized in-site and in mass could work as a source of heating system to provide energy for poultry places and raising pigs. They could be participants on their own progress of their communities leading projects with multilateral NGOs who surely will support this initiatives.
- Within the sample of pilot project in order to measure the profitability of the project, I realized that scalability is a big issue here, due to costs of production get higher every time we increase the capability of production and its profitability is slightly higher than zero in some months but not attractive for a private investor, however, the relevant side of the project is the long term impacts which could be channelized through of it. Like strong partnerships with local government to support education, training local people to teach others and being auto-sufficient with the energy for schools, besides the advantage of reactivation of local economies could bring to the arena new opportunities along communities bringing also development in roads and transportation. Social innovation is made by humans for humans and is key to involve the users into the problematic to listen their problems and how they perceive a potential solution within the idea-generation process.
- Participation of stakeholders like banks and society is key. Firstly, to fund it and receive the needed support in similar projects. Biogas generation is likely to be funded by any multilateral organization which seeks prosperity, sustainability and development for vulnerable communities in order to reduce poverty and access to public services. And in this case starting from a pilot project with centralized communities and measure it through a horizon of 3-5 which bring to the table real facts to make it scalable and improved (even in short term)

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