HOUSEHOLD BIOGAS ADOPTION; A CASE STUDY OF SHUMER, PEMAGATSHEL DISTRICT, BHUTAN

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Finally, I believe this research would be useful to scholars, students, researcher and to all those who are looking information on the adoption of household biogas technology.

DEDICATIONS

I dedicate this book to my son Tashi Righden Dorji, daughter Neychog Choieng Oselma and Melam Rigzang Dolma and my wife Sonam Yangchen, brother Leki Dorji and sister Dechen Pema and my loving parents Mindu Wangdi and Karma, who supported me thick and thin throughout my life.

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LIST OF ACRONYMS

ADB	Asian Development Bank
BBP	Bhutan Biogas Project
BDBL	Bhutan Development Bank Limited
DoL	Department of livestock
DRE	Department of Renewable Energy
€	Euro
FGD	Focussed Group Discussion
HH	Households
LPG	Liquid Petroleum Gas
M^3	Cubic Metre
NSB	National Statistical Bureau
Nu	Ngultrum (1 Euro = 78 Nu.)
LPO	Livestock Production Officer
PES	Payment for Environment Services
REDCL	Rural Enterprise Development Corporation Limited
RLDC	Regional Livestock Development Centre
SDG	Sustainable Development Goal
US$	United States Dollar

ABSTRACTS

In Bhutan biogas energy can be used as an alternative energy for wood to meet the energy demand in the rural populace with effective management and utilisation of the biogas plant. Despite various benefits of biogas technology, biogas adoption has been less than anticipated. As of today, District Livestock Sector lacks knowledge on the reasons why the adoption of biogas is less than anticipated. The intended goal of this study was to make recommendation for examining various factors influencing the adoption of biogas technology to recommend the District Livestock Sector to adapt or change its policy. Using descriptive analysis of cross-sectional data, the factor hindering the biogas adoption by the rural households of Shumer block, Pemagatshel, Bhutan were examined. Semi-structured questionnaires were used to collect data from 32 respondents,16 adopters and 16 non-adopters. Two focus group discussions with both biogas adopters and non- adopters from were carried out, while 4 key informants participated to validate the findings. The study found out that education, awareness, male headed household, age, large household size, higher cattle numbers and stall feeding positively influence adoption of biogas plants. While, most of the farmers showed their interested to adopt biogas technology but the high installation cost, low subsidy support from the government, low income of famers, absence of biogas sale agent, lengthy procedural and difficulty in availing credit were some of the barrier in the study area. Innovation characteristics were also associated in diffusion of the technology.

On the basis of the findings the study recommends the District Livestock sector (DoL) to trap the potentials of biogas, conducive policy framework reforms for wider adoption. policy strategy, such as developing soft loan with lower interest rates (4-8%), tailor made loan scheme for the poor, shortening of documentation procedural at the community levels. While, institution of the biogas agent in the district can help in resolving the current issues on the delay in replacement of spare parts and equipment for biogas.

Key words: Biogas, barrier, adoption, policy, credit, diffusion

CHAPTER 1: INTRODUCTION

This chapter provides the background for the study on the biogas adoption in Shumer, Pemagatshel, Bhutan (section 1.1) and includes the problem statement (section 1.2), research problem and objectives and research questions (section 1.3).

1.1 Background

Bhutan is perched between India in the south and China in the north and within the Himalayan mountains. It has an area of 38,394 with a population of 727,145 (NSB, 2018). According to Bhutan Living Standards Survey Report 2017 (Table 1), Bhutan has 164,011 households of which 36% (59,044) are in the urban area and 64% (104,967) in rural areas (NSB,2017). Bhutanese family size in a rural area is 4.4 in rural areas (NSB, 2017). Conservation of the environment is one of the four development philosophy pillars of Gross National Happiness (GNH). Bhutan has a forest cover of 70.5 percent in 2017. NSB (2017) reported that the monthly per capita household expenditure was US$ 85.75 (1 US$ is pegged at 72 Bhutanese Ngultrum) in the rural areas while the mean per capita expenditure of households in the poorest per capita consumption quintile was US$34.28 per month.

Bhutanese depend mainly on energy sources like electricity, firewood, Liquid Petroleum Gas (LPG) for cooking meals and heating the home. The report stated that electricity from hydropower is the most widely used source of energy for cooking for both urban 99.1% (58,513) and rural 92.5% (97,094) households. While 95% (56,092) of urban households also use LPG gas as the source of energy for cooking as compared to rural households of 57.8% (60,671). In addition to electricity and LPG, one-third (33.3%) of rural households in Bhutan also use wood as the source of energy for cooking (NSB, 2017). Although, firewood is the important source of energy for cooking and heating for Bhutan's rural populace, firewood collection from the forests is becoming difficult of late due to the restriction imposed by the government. The forests are managed by the communities which further restricts its use.

Moreover, the government aims to protect the natural forest by providing access to alternative sources of energy to the households. Liquid Petroleum Gas (LPG) is another source of cooking energy which is imported from India. Since it is becoming expensive these days it is not a sustainable solution. Moreover, the rural people do not prefer to use LPG as they do not have the knowledge and skills required for cooking and a perceived belief that the meal prepared by LPG has less taste compared to the meals prepared on firewood.

Table 1:Energy source for cooking in Bhutan (2017)

Household category	H/H numbers	Electricity	LPG	Wood
Urban Households (36%)	59044	58513(99.1%)	56092(95%)	
Rural Households (64%)	104967	97094(92.5%)	60671(57.8%)	34639(33%)
Total households	164011	155607	116763	34639

Source: Adapted from NSB (2017)

The first use of biogas in Bhutan dates to 1980s but household biogas technology gain momentum at the beginning of 2010, under the initiative of Department of Livestock, initiated Bhutan Biogas Project a joint program of Asian Development Bank (ADB) and Department of Renewable Energy (DRE), SNV the Netherlands Development Organization and Bhutan Development Bank Ltd. (BDBL). The project was instituted in four southern districts of Chukha, Samtse, Tsirang, and Sarpang which have the ambient temperature for biogas production and later it was spread to rest of the 16 districts (Bhutan Biogas Project, 2018). As of March 2019, there are 5461 household size biogas plants whole over the country. There are 550 community mason and 297 staff under Livestock department trained on biogas technology.

In the Bhutanese context, there is existing policy support that provides subsidy support of biogas construction of US$ 162.5 for a household size biogas construction. Besides the subsidy, the government provides awareness and training beforehand to the persons who are interested in biogas. Furthermore, the government through some projects provide construction materials for dairy shed housing which enables in the collection of dung for the biogas production to encourage people to adopt biogas technology. The government also support credit facilities to install biogas from BDBL to promote biogas adoption.

The biogas technology was introduced at Pemagatshel district in 2014 with the training of 13 extension officers and 11 farmers. Table 2 indicates a total of 266 households have a biogas plant installed, which is less than the anticipated. The table also shows that the number of households having such a plant is decreasing form 2016-2017 onwards. Currently, the district has 266 numbers of biogas, 32 community mason and 22 staff trained (District Livestock Sector, 2018). The biogas adoption since inception in 2014 in Pemagatshel District has been indicated in Table 2.

Table 2:Biogas adoption under Pemagatshel

Name of Blocks	**Household Biogas adopted 2014-2018**				**Total**
	2014-2015	**2015- 2016**	**2016- 2017**	**2017-2018**	
Chimung	0	0	1	0	1
Chhoekhorling	1	20	6	2	29
Chongshing	2	10	8	5	25
Dechhenling	17	0	0	0	17
Dungme	0	0	12	5	17
Khar	0	2	4	5	11
Nanong	0	6	0	4	10
Norboogang	8	20	0	11	39
Shumer	34	18	12	4	68
Yurung	0	4	2	0	6
Zobel	9	20	0	14	43
Total	**71**	**100**	**45**	**50**	**266**

Source: DLS, Pemagatshel (2018)

The government is keen to promote biogas technology as a sustainable energy source technology as one of the mitigations in lieu of the worsening global climate change and protecting the environment. Biogas can endorse the twin objective of environmental and livelihood improvement (Balgah, et al., 2018). It helps to reduce the dependency of fuelwood and save time from collecting firewood for cooking and heating and can contribute towards mitigation of climate change through the management of dung and reduction of usage of biomass energy (firewood). Moreover, the use of biogas technology can address Sustainable Development Goal (SDG) 7 which is the clean and affordable of energy ultimately, contributing to the SDG 13 (Climate Action). Sachs, et al. (2018) reported that Bhutan is ranked 83 in the 2018 Global SDG Index ranking with 65.4 score from 156 countries. The government has prioritized three SDGs namely No Poverty, Climate Action and Life on Land in the 12th Five Year Plan (Goal 1; Goal 13; and Goal 15 – Life on Land) for immediate actions. Bhutan has always committed to remain carbon neutral (Climate Action) and be a world leader in terms of promotion and conservation of biodiversity (Life on Land).

1.2 Research Problem and objective

The Bhutanese government through the Department of Livestock has been helping and spreading biogas technology as one of the sustainable sources of energy. These exertions were intended to motivate rural households to adopt biogas as an alternative source of energy and move away from the conventional forms of energy like firewood which have negative effects on the people's health and environment (Bhutan Biogas Project, 2013). Government of Bhutan views biogas technology as source of low-cost renewable energy for rural households. As a result, through various projects like Bhutan Biogas Project support, government has attempted to promote biogas in the rural part of the country.

However, despite various benefits of biogas technology, biogas adoption has been less than anticipated and it is perceived that many factors tend to have played largely for slow take-up although the economic and environmental benefit from biogas is seen to be substantial as seen by the government. As of today, District Livestock Sector lacks knowledge on the reasons why the adoption of biogas is less than anticipated in Shumer sub-district(block) under Pemagatshel district. This study examines the characteristics like innovations, institutional, farmers and farm characteristics that constraints to adoption of biogas in Shumer Block under Pemagatshel in Bhutan and explores factors that could influence the adoption of the technology

The goal of this study is to examine various factors affecting the adoption of biogas technology to recommend the District Livestock Sector (DLS) to adapt/change its policy.

1.3 Research Question

What are the factors affecting the adoption of household size biogas technology among farmers in Shumer, Pemagatshel?

Sub research questions

1. What are the innovation characteristics that influence the adoption of biogas?
2. What are institutional characteristics affecting biogas adoption?
3. What are the characteristics of the biogas plants in Shumer block?
4. What are the farm characteristics that influence the adoption of biogas?
5. What are the farmers characteristics that influence the adoption of biogas?

CHAPTER 2: LITERATURE REVIEW

This section focuses on literature related to biogas adoption to understand the factors affecting the adoption of biogas technology among biogas farmers in Shumer Block under Pemagatshel. The literature review focuses on four dimensions such as innovations (section 2.1), institutional (section 2.2), farmers (section 2.3) and farm characteristics (section 2.4) and conceptual framework (2.5) are explained.

2.1 Innovation characteristics

Robinson (2009, p.1) using Rogers theory on adoption in 1995 defined "innovation is an idea, behaviour, or object that is perceived as new by its audience". While, Put (1998, p. 15) using Van den Ban and Hawkins define as "innovation is an object, a method or an idea which is regarded as new by an individual, but which is not always the result of recent research". He further explains that whether an innovation is new is of no concern. What matters is whether it is new in the eyes of the individual and by its nature existing technology is supposed to replace with an innovation.

Put (1998) indicate that multidimensional nature makes innovation adoption highly complex. The first adoption is highly dependent on contextual factors like weather, topography which are beyond the control of change agencies and individuals. Secondly, adoption depends on deemed needs and problems of potential adopters. Thirdly, characteristics of innovations depend on how these are perceived by potential adopters considering the indigenous technologies. Fourthly, it depends on the organisation and change agent. Fifthly, it depends on the decision more than the potential adopter's characteristic and finally, it depends on its social structure, its norms any access to information, resources and marketing opportunities.

Rogers (1995, pp. 15&16) writes that "innovation has five qualities; relative advantage, compatibility, complexity, trialability and observability that can influence the adoption of the innovation". He described relative advantage as the degree to which an innovation is seen as better than the idea, program, or product it replaces. The author does not limit the measurement to economic terms, but satisfaction, social prestige and convenience are also important factors. The greater the relative advantage of an innovation, rapid the adoption of innovations. Relative advantage refers to the extent the innovation is perceived to be better than other related options and can be determined by a variety of factors. The relative advantage may be economic (i.e., innovations that can replace or supplement more expensive items), or it may be some other advantage, such as relative effectiveness (Dearing , et al., 1994).

While, Put (1998) ascribed that the relative advantages are more obvious, more clearly visible, occur rather immediately after adoption (short-term character). He states that if the relationship between cause and effect, between adoption and benefits, are not easily or immediately discernible, potential adopters might refrain from the adoption or adopt to a lesser than full extent. High installation, operating and maintenance costs, which puts it out of financial reach of many rural households have been identified as one of the major barriers that limit widespread dissemination of domestic biogas technology (Surendra et al., 2014).

Wahyudi (2017) reported that the relative advantage of biogas is the most determinant attribute to speed up the biogas adoption rate. It is perceived that owning a biogas plant generated more socio-economic benefits compared to previous technology. The biomass fuels, such as dung briquette and firewood are relatively cheaper than modern fuels like LPG and Kerosene. However, burning biomass fuels incurs higher health costs. Further, the author indicated that biogas faces intense competition with other fuel substitutes available in the market like which are ease for procurement and consistent. Low biogas production which is insufficient for cooking during the winter season has been reported by Kaniyamparambil (2011) as cited by Mittal, et al.(2018) has forced the biogas users to switch to other fuels. In most of the developing countries, biogas has been promoted as a renewable, cleaner and cheaper energy source, especially for cooking, as compared to alternatives such as firewood and kerosene (Bedi, et al., 2017).

Compatibility refers to the extent innovation is consistent with the values, beliefs, needs, and experiences of the public. The public is more likely to feel comfortable with an innovation that is congruent with their pre-existing values, beliefs, and needs (Atwell , et al., 2009). While, Rogers (1995) describe combability as the degree to which an innovation is perceived as consistent with the existing values, norms, past experiences and needs of potential adopters, with their social system and with the local physical environment. An idea or innovation that is incompatible with the values and norms has lesser chances to be adopted as an innovation that is compatibility. Objections towards using human and animal waste as a raw material are very specific to the local values and culture have been one of the reasons of people not adopting biogas (Rupf et al., 2015). Factors like the ease of procurement, fuel price, assurance of fuel supply have an influence on household fuel choices (Bansal, et al., 2013).

The third property of innovation is complexity defined as "the degree to which an innovation is perceived as difficult to understand and use (Rogers, 1995, p. 242)". The ideas which are simple are more likely to adopt rapidly unlike the innovation which needs to develop skills and understanding. While, it is understood that technical skills are not required to use firewood as a means of fuel for cooking, but you need technical skills to operate the biogas. There is a large amount of concern and worry about renewable energy initiatives due to uncertainty and perceived complexity of these innovations. These initiatives are complex not just in terms of the level of understanding required but also in terms of the consequences of adopting these innovations to the environment, economy, individual budgets, and employment opportunities for future generations.

The fourth characteristic of innovation is trialability: "the degree to which an innovation may be experimented with on a limited basis (Rogers, 1995, p. 243)". The innovations that are trailable by learning by doing can be adopted quicker than the innovations that cannot be available. As such, biogas technology is not triable, potential adopters must rely on the information on the adopters or someone should convince. If the potential adopters are not convinced, it is likely that the potential adopters may not adopt it. Although it seems that individuals may be willing to try out some of these innovations, there are several barriers to their actual adoption. These barriers include a lack of infrastructure, lack of opportunities to test out these alternative energy resources, and resistance to change. Even if there are intentions to adopt or at least a desire to try out new innovations, environmental constraints such as a lack of resources or infrastructure will inhibit the process (Yzer, 2012).

The fifth characteristic "observability is the degree to which the results of an innovation are visible to others (Rogers, 1995 p. 244)". The more visible the innovations, the higher the chance of adoption areas such visibility can stimulate peer discussion with the friends, neighbour of the adopters and often seek for more information about the innovation. Observability: Examples of instances where renewable energy initiatives have provided energy effectively can be persuasive. Observing others is a key tenant of social cognitive theory and is consistently related to the development of self-efficacy (Bandura, 1997). Additionally, observing others may help develop perceived norms, particularly if those who are being observed are opinion leaders (Rogers, 2003). Both self-efficacy and perceived norms in favour of the behaviour are related to behavioural intentions.

2.2 Institutional Characteristic

Access to credit institutions, policies, extension services, awareness of the training also plays a positive role in the adoption of the technology. If there is good policy to support the technology, chances of adoption will be higher compared to the policy which does not favour the potential adopters. While education and extension services can also influence the adoption of innovation. Institutional plays a great role in the adoption of the technology. Dendup & Arimura (2019) indicated as per the Bhutan Living Standard Survey (BLSS,) approximately 39% households more likely to adopt clean cooking fuel with access to information while, 49% of households are less likely to adopt dirty fuel (firewood)

Kelebe, et al.(2017) indicated that access to credit, electricity, and all-weather roads positively affect biogas adoption decision of households. Improved adoption of biogas due to credit accessibility in Northern Ethiopia has been reported too (Mengistu , et al., 2016). The study carried out in Pakistan reveal that awareness regarding the pros and cons of using biogas were positively influencing the adoption of a biogas system in the area (Jan & Akram, 2018).

Bhutanese government also support credit facilities to install biogas from BDBL to promote biogas adoption. Although Biogas saves lots from expenses but does not generate cash, unlike other investments. Therefore, both farmers and financial institutions are not in favour of processing the credit for biogas (Bajgain, 2008).

Adoption is likely to follow because of organizations (adopters) having pre-existing knowledge and skills in place to incorporate new knowledge or innovation while legislation and regulatory agencies and accreditation standards during adoption phase are can increase adoption (Aarons, et al., 2011). The authors further highlighted that the presence of external policy and regulation during the pre-adoption phase can positively influence innovation adoption. A study carried out by Sun et al. (2014) in rural China showed that the adoption rate of biogas increased with subsidy policy in place. A similar finding in China was reported that as soon as the subsidy was downsized, the adoption rate dropped (Rajendran, et al., 2012). However, Bhattarai, et al.(2018) reported that despite Nepal starting subsidy program on biogas technology in the 1970s, the program was not geographically targeted to poor and only 5 % of subsidy-eligible households have adopted biogas. However, Wang, et al.(2016) reported that the most of the policies in many of the countries focus mainly on construction and does not pay attention towards the management and maintenance of the biogas plant, resulting in high rate of in adoption and waste of resource and suggested that income disparity of farmers among regions must be considered for policy application if the digesters to keep on working for 20 years.

Erick, et al. (2018) describes technology adoption while studying factors influencing the adoption of biogas technology in Meru County, Kenya to understand the following issue of technology adoption. Rogers, (1995) defines technology adoption as the level at which an innovation is chosen to be used by a person or an organization. Abukhzam & Lee(2010) indicated that adopting technology depends on numerous elements which purpose a targeted user to adopt or reject. They include; perceived usefulness and ease of use, facilitating conditions e.g. availability of government support and managerial support, technology readiness and social influence. These factors can make a positive or negative contribution to technology adoption. Customers may also reject some technologies since technologies are not in line with their values, beliefs and past experiences. The successful implementation of any innovation is primarily determined by the user's attitude (Davis, 1989). However, factors such as technology characteristics (e.g. perceived usefulness and ease of use, compatibility, reliability, security), organisational and managerial characteristics have been found to be key instrumental factors affecting user's attitude towards adoption or rejection of a technology. These factors must be explored to understand why farmers of Shumer either adopt, not adopt or have stopped to adopt the biogas technology.

2.3 Farmer characteristic

Lewis and van der Ban (2004) states that education, large size units, higher social status, favourable to credit, opinion leadership, social participation and mass media are some of the variables which have positive relationship towards the adoption of the innovations (Table 3).

Table 3:Positive relationship between adoption index and selected variables

Variables	% of studies	Number studies
Education	74	275
Larger Size units	67	227
Higher social status	68	402
More favourable to credits	71	28
Opinion Leadership	76	55
Social participation	73	149
Mass media exposure	69	116

Source: Adapted from (Leeuwis & Ban, 2004)

A study conducted in Pakistan by Yasmin & Grundmann (2018) reported that older and wealthy farmers are more likely to adopt biogas technology. Similar finding from the study conducted in North East India by Raha, et al.(2014) indicated that householders belonging to higher income groups installed the biogas plant under the National Biogas and Manure Management Program units. Subsequently, enhanced yearly income, increased level of education, empowering women, is likely to increase the adoption rate of biogas plants (Kabir, et al., 2013). Family size, level of education, female-headed households tend more to adopt the biogas technology as compared to their male counterparts and distance to the nearest market negatively affected the adoption decision of the households (Kelebe , et al., 2017). A similar finding was also reported by Rahut, et al., (2016) that wealthier and more educated households in Bhutan rely more on clean sources of energy like liquid petroleum gas and electricity while poorer households depend on dirty fuel such as fuelwood and kerosene. The female-headed households are preferring for cleaner fuels than male-headed households.

However, a study conducted in Northern Ethiopia showed that male-headed households are more likely to adopt the technology than female-headed ones. (Mengistu , et al., 2016). It was reported by Kabir, et al. (2013) that larger family has more working members in the household and thus more labour force for routine biogas operation and maintenance activities can positively influence biogas adoption. However, larger households could also use their family members to other income-generating activities due to the heavier burden of dependence on insufficient family resource. This may also negatively influence biogas adoption. A similar finding was reported that households with more members can negatively influence over adopting clean fuel as they have more labour force for the collection of firewood (Nepal, et al., 2011). The upfront installation cost of biogas plant is significantly higher than the monthly household expenditure of low-income households in rural areas makes it difficult to afford biogas plant even after receiving the capital subsidy for the low-income households in rural areas (Bansal, et al., 2013)

2.4 Farm characteristics

Farm characteristics like the herd size, breed of cattle, availability of water, and breed of the farm, availability of pasture land, feeding system have an influence of adoption. The absence of water can limit the operation of the farm in terms of cleanliness and clean drinking water for the cattle. while the different feeding system like stall feeding and open grazing could differ in the amount of dung produced. Bigger size biogas plants can produce higher biogas production that can meet the energy requirement of the households. Bigger farm size could have enough substrate required for the biogas plants while the small farms will not have enough to feed the Biogas Digester. The bigger and superior cows, the more the dung will be produced comparing to the traditional cows. Such farm characters can influence the adoption of the biogas.

The more the herd size and the better the breed, the more chances of adoption. This is because, the more the cattle head, more dung will be produced. Similarly, local cattle produce less dung comparing the improved breed of cattle. Such farm characteristics can influence the adoption of biogas. Insufficient cattle head to supply substrate is primarily considered as the main issue for low adoption of biogas technology in rural areas based on the study conducted in North – East India. People are not aware of other feedstock alternatives that can be used in the digester (Raha , et al., 2014). They further ascribed that minimum ownership of 2 to 3 cattle do not fully ensure the consistent supply of dungs to the biogas plant. The factors like cattle moving around grazing and working in the fields result in under-collection of cattle dung eventually trigger to improper functioning of the biogas plant because of under-feeding of the digester. Similar findings were reported in Bangladesh by Kabir, et al., (2013) that it is likely to increase adoption of biogas with the increase in cattle heads.

The study conducted by SNV on the experience from Asia and Africa reported that farmers rearing six adult pigs or a minimum of three heads of stall-fed cattle can produce enough biogas to meet daily basic cooking and lighting needs (Ghimire, 2013). It shows that the herd size of the farm can influence the adoption of biogas as there is need of dung for feeding the digester of the biogas. Shed keeping or stall feeding has an advantage over the free-range grazing that the dung can be easily collected, stored, or composted and applied to the crops (FAO, 2018). Similar findings were reported by Bajgain (2008) reported that the introduction of the stall-feeding system in the dairy farmers in Bhutan by the Livestock Department will help to get more dung for biogas generation. This type of feeding system can ease the dung collection and generate more dung unlike in the open grazing system where dung collection can be tedious. Therefore, the type of feeding system can also influence the adoption of biogas.

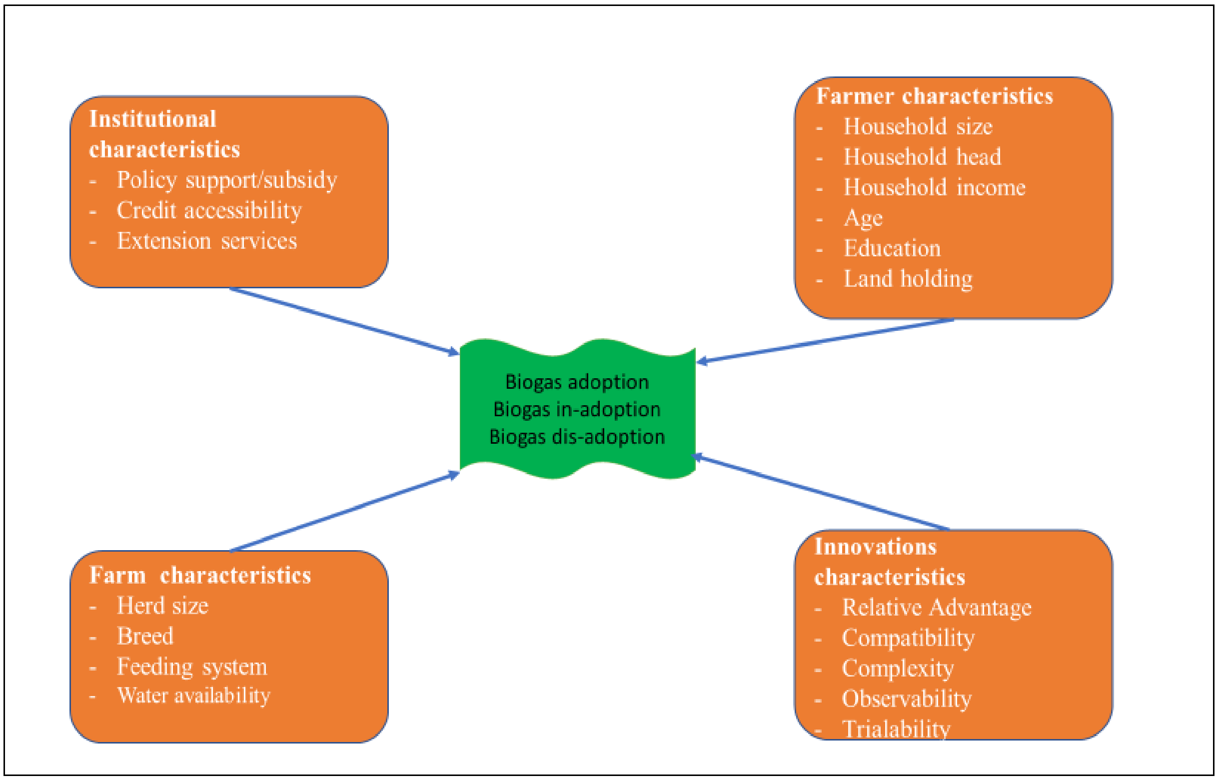
Family-type small biogas systems predominantly exist in the rural areas in India with capacities ranging from $1m^3$ to $10\ m^3$ biogas per day and mostly small-scale plants are managed by individual households to generate energy for self-consumption Mittal, et al.(2018). Most of the biogas users in Bhutan used

4m^3 and 6m^{3}capacity biogas plant which requires a minimum of 20 kg - 30 Kg of dung daily to be fed to the digester.

2.5 Conceptual framework

The conceptual framework gives a diagrammatic representation of the variables in the study. It shows that the core concept of biogas adoption will be classified under four dimensions of characteristics of innovation, institutional characteristics, farmers characteristics, and farm characteristics (Fig. 1). It indicates that the policy support and subsidy, extension services, household income, size of land and size of household and herd size and dairy feeding type could influence the decision to adopt biogas technology. Further, relative advantage and compatibility of the biogas technology over other energy

Figure 1:Conceptual Framework



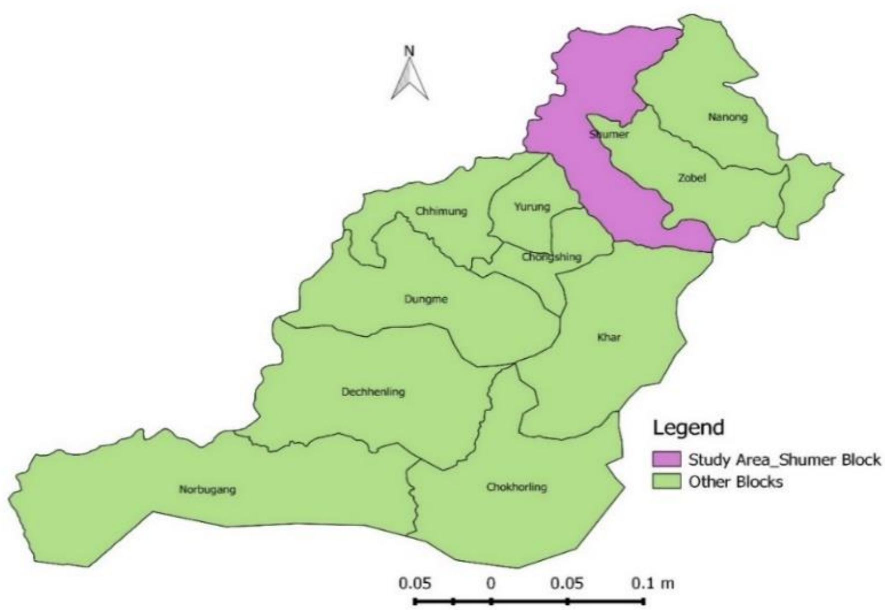
***Source**: <u>www.researchgate.net</u>(adapted from adoption IPM & conservation of Agriculture)*

CHAPTER 3: METHODOLOGY

This Chapter focuses on research methodologies and strategies. The section 3.1 explains the selection of research location followed by 3.2 with research strategies. While 3.3 explains on the data analysis process, 3.4 describe on the research period. The challenges and the limitations is presented in section 3.5 and the chapter concludes with ethical considerations (3.6).

3.1 Selection of Research location

Shumer block (see map 1) under Pemagatshel district was selected for this study, has an area of 92.56 sq.km with 700 households and a population of 6971 as of 2018 (Block Office, 2018). For their livelihood, people mainly depend on livestock and agriculture and currently, it has two farmers dairy groups. Although Shumer has a huge potential of installing biogas plants having the highest number of households and the highest number of cattle in the district, the biogas plant has decreased from 34 in 2014-2015 to 4 in 2017-2018 (see table 2). Still, Shumer has the highest number of biogas plants in the district with 68 plants.



Map 1: Study area

Source: Dorji(2019)

3. 2 Research Strategies

3.2.1 Secondary data collection

Desk study was done to collect the secondary data like statistics, research area description, policies using National Statistical Bureau (NSB), Local Government Office, Shumer, District Livestock Sector office about the proposed project. The literature review was done on institutional characteristics, farmers characteristics, farm characteristics and innovation characteristics that influence adoption using relevant scientific journal articles, reports from the internet. Further, some of the relevant books from the library have been referred to get additional information.

3.2.2 Primary data collection

A case study using qualitative methods of data collection was used for the study as it brings out more personal answers from the respondents knowledge and feelings and are a good way to look into people´s perspectives and understanding (Brymin, 2008). The main source of data such as institutional characteristics, farmers characteristics, farm characteristics and characteristics of innovation were collected using a semi-structured interview from 16 biogas users and 16 biogas non-users in line with the conceptual framework.   In-depth interviews allow interviewees talk freely with minimum guidance from the researcher, and in this way, more information can be revealed (Brymin 2008). While, quantitative research method is only based on numeric data, there is less chance for the researcher to become biased and make personal interpretations (Brymin, 2008). The selection of the respondents was at least 40% of male and female representation. Minimum of 40% representation of male and female-headed households using purposive sampling from villages of Bartseri (4HH biogas users & 4HH non-users), Yalang (4HH biogas users & 4HH non-users), Khothakpa (4HH biogas adopters & 4HH non - adopters) and Gamung (4HH biogas users & 4HH non -users) participated in the survey. These villages were chosen as they have most of the biogas adopters in Shumer block. The respondents and FGD members were provided light refreshments.

In addition, qualitative investigations were conducted in the form of two focussed group discussions (FGD) comprising 10 participants each one with biogas users and one with non-biogas users using set of topic list. This focussed group respondents were selected from the above villages who were not involved in the semi-structured interview using the same criteria set above to triangulate data collected from interviews with key informants and respondent. Further, the FGD (figurer 2) was carried out to generate additional information which might have left out from the semi-structured interview of the individual respondents.

Figure 2: Focus Group Discussion

Source: Focus Group Discussion (Dorji, 2019)

Four key informants (expert views) comprising of Regional Director (Regional Livestock Development Centre), District Biogas focal person (District level), Shumer Livestock Extension Officer (Shumer Block) and Credit Officer (BDBL) represented in this study. The first three key informants were interviewed considering the rich experience on the biogas technology in different level of working field. Using a topic lists, collected information on institutional characteristics and their opinion in the biogas program relating to the findings. While the fourth key informant was interviewed to understand the in-depth information on credit facilities in the biogas program.

Observation was also done in the field to validate the result wherever possible like checking of feed stock, intensity of heat from the biogas. An observation schedule was developed to ensures information gathered is free from respondents' bias gather information in the field (Sekaran & Bougie , 2010) . Such observation provided an opportunity to have a better understanding of ground reality in the research area. Informal conversations with few farmers which were not included in the sample size were also done wherever possible to find additional information in the study areas.

3.3 Data Analysis

Data analysis was done using an excel spreadsheet and analysed quantitative data collected from the individual respondents, focus groups, semi-structured questionnaires, and key informants. Analysis of the data were done using qualitative thematic content analysis technique. The data were first transcribed and read to identify meanings. This was followed by generating theme statements. In the end, a table or matrix was created for each theme, showing all the related meaning units to exemplify the themes. In addition, the different relations and connections that exist between relevant issues in line with dimension and indicators which resulted from the better-elaborated literature review were analysed.

3.4 Research period

The data collection and processing duration was eight weeks which started at the end of the last week of June 2019 (Annexed 2). The researcher obtained administrative approval from the local government office (block head) for conducting research in Shumer block, Pemagatshel district. Preliminary field visit to the research sites was done along with community leader in the last week of June 2019. The community leader introduced the researcher to the interviewees and were briefed on the interview which took place from the first week of July. The data collection started with interviewing the respondents, followed by focussed group discussions and with the key informants.

3.5 Challenges & Limitation

All the researchers face encounters during the research work and had my shares too. During the data collection due to incessant rains that cut off the road connectivity to some of the study areas. Collecting data alone was challenging as at times I had to facilitate a group while recording the information from the respondents at the same time. I had to walk for hours to reach the respondents and one time I was nearly buried by a landslide.

While, the limitation in this study was that it was a purposive sampling which might have left the potential respondents who might have different views to share. The result may have influence due to smaller sampling size (16 biogas users & 16 Non-users). As stated by Brymin (2008), small sampling size have a greater chances of sampling error, while increased sample size would also increase the precision of a sample and thereby reduce the chance for sampling error. While, some of the respondents were in haste to attend the agricultural farm work during my visiting period and may eventually under contributed to the findings. I have a good background of biogas and might positively influence on the width of the research. Since, I am known to the area by my position as a Livestock Production Officer, as a result this could have influence on the finding by trying to please me. The incentives like providing refreshment to the respondents may have help to contribute more to the findings.

3.6 Ethical considerations

Ethical clearance and administrative approval were obtained to the relevant organisations to undertake the research at Shumer block, under Pemagatshel. In this research all the participants were given full confidentiality and prior to each interview the participants were briefed about the goal of the study. Respondents were assured with the confidentiality on their personal contribution to this research. It was agreed that the information would not be revealed at any cost and that the information would solely be used in my research studies. All the participants consented to participate in my research**.**

CHAPTER 4 RESULTS

This section focuses on findings of the study related to biogas adoption to understand the factors affecting the adoption of biogas technology among biogas farmers in Shumer Block under Pemagatshel. The section 4.1 explains about the background of the respondents, key informants and participants in the Focus Group Discussion (FGD). The section 4.2 describes about institutional characteristics followed by innovation characteristics(4.3), characteristics of biogas (4.4), Farm characteristics(4.5) and Farmers characteristics that influence adoption of biogas(4.6).The finding is based on the response from the 16 biogas adopters who still use biogas and 16 non-adopters who have never adopted and never used biogas technology.

4.1 Background of the respondents, key informants and participants in the Focus Group Discussion

In total 32 respondents were interviewed; 16 of them adopted(users) biogas technology and another 16 who had not adopted the technology. In addition, 4 key informants were interviewed and a total of 2 FGD were held. Table 4 indicates that 50% biogas adopters and 50% non-adopters' respondent were interviewed in this study with 40.6% male and 59.4% female representation. The results also found that 7 (53.9%) out of 13 male respondents adopted biogas plant, while 9 (47.4%) out of 19 female respondents adopted biogas plants. The result from the individual interview respondents found that majority of the biogas technology has been introduced by District Livestock Sector (DLS) as it is the main implementing agency while, are initiated by block administration through the support from the block development grant. The key informants comprised of livestock officers from Regional, district and block level who have rich experience on biogas technology. All the key informants have a minimum of bachelor's degree except for one key informant who holds a master's degree.

Table 4:Sex of adopters and non-adopters in absolute numbers(abs) and percentage(%)

Sex	Adopter		Non-adopter		Total	
	Abs.	**%**	**Abs.**	**%**	**Abs.**	**%**
Male	7	53.9	6	46.1	13	100.00
Female	9	47.4	10	52.6	19	100.00
Total	16		16		32	

Source: Respondents interview (Dorji, 2019)

It indicates that 72.2 % (13/18) of the adopters' respondents and 27.8 % (5/18) non-adopters were literate. They have either attended school or non-formal education. While, 78.6% (11/14) of non-adopters were found to illiterate in contrast to 21.4% (3/14) adopter (table 5). It also shows that literacy level has positively influence adoption of biogas in the study area.

Table 5:Literacy level of the adopters and non-adopters in absolute numbers and percentage

Literacy	Adopter		Non-adopter		Total	
	Abs.	%	Abs.	%	Abs.	%
Literate	13	72.2	5	27.8	18	100.00
Not literate	3	21.4	11	78.6	14	100.00
Total	16		16		32	

Source: Respondents interview (Dorji, 2019)

The finding in the table 6 shows that the average age of the respondents was 43.8 while the average landholding size of the respondents was 1.9 acres in the Shumer block.

Table 6:Average age and average land holding size of the adopters and non-adopters in absolute numbers

Variables	Adopter	Non-adopter	Total
Average age(years)	42.75	44.875	43.8
Average land holding size(acres)	2.6	1.2	1.9

Source: Respondents interview (2019)

4.2 Institutional characteristics affecting biogas adoption

4.2.1 Policy support/ Subsidy

Table 7 indicates that none of the non - adopters availed readily available subsidy support provided by the government while all the user took away the subsidy support for adoption of the biogas. The assured subsidy can be availed by any of the aspiring biogas adopter at any time, but the non-adopters did not want to take away the subsidy for biogas plant construction. While, 68.8% of the adopters feels that it is difficult to get the spares parts timely during the break down of the plant due to non-existing of biogas agent in the district.

Respondent # 7

"Although there is subsidy support of €150 from the government for biogas program, I still cannot adopt biogas being a poor farmer. So, I gave up the idea of applying for the subsidy".

From the above statement, it can be interpreted that despite having subsidy support in place for the aspiring farmers for biogas adoption, the poor section of people still cannot afford the adoption of biogas technology even with the subsidy support. The existing low subsidy for the biogas construction has been emphasized during the focussed group discussions and proposed for the increase subsidy if poor people have to adopt it. They proposed for minimum of 50% subsidy and suggested to come up with separate subsidy package for the pro-poor section of the people.

The focussed group discussion with the biogas adopters feels that the subsidy encouraged them to adopt biogas, but it was still not enough to meet the expenses of biogas plant construction. They had struggle lot to complete the biogas plant. Many of the non-adopters responded that the subsidy is likely to reduce the cost of construction they cannot top up the additional expenses on the subsidy to complete construction of the biogas plant. They respondents stated that the subsidy support of €150 is felt very less and the low-income group of people cannot afford the technology. Suggestions were made to review the subsidy package and to increase the subsidy from 30% to at least 50%. The focussed group discussion also suggested to design a separate package for the poor section of inspired potential adopters. The key informants substantiated that the subsidy packages are not availed by the poor section and by the richer section of people despite awareness from the livestock sector. At the end the subsidies for biogas adoption are availed mostly by middle class of farmers.

Table 7:Institutional characteristics

Variable		**Adopters**		**Non-adopters**		**Total**	
		Abs	%	**Abs**	%	**Abs**	%
Subsidy support	Uptake	16	100	0	0	16	100
	Not availed	0	0	16	100	16	100
Biogas equipment and spare parts	Ease for biogas equipment accessibility	5	31.3	0	0	5	100
	Difficulty for biogas equipment accessibility	11	68.8	0	0	11	100
Credit accessibility	Difficult	11	47.8	12	52.2	23	100
	Easy	5	55.6	4	44.4	9	100
Access to extension services (related to biogas)	Awareness availed	16	76.2	5	23.8	21	100
	Awareness not availed	0	0	11	100.0	11	100

Source: Respondents interview (Dorji, 2019)

4.2.2 Credit Accessibility

The result from the table 7 indicates that 47.8 % of biogas adopters and 52.2 % of non-adopters feels that credit accessibility is difficult. While, 55. 6% adopters and 44.4% non-adopters stated that availing credit is not a problem. Most of the respondents felt that the lengthy procedures and delay in fund release demotivate them for availing credit from the Bhutan Development Bank Limited (BDBL). The collateral of handing over of the land registration certificate as a prerequisite for release of loan by the BDBL also was hindering farmers from availing credit.

The key informant corroborated that the delay in the release of the fund is due to the different institution involved and institutional policy change. Moreover, the bank obtains the land registration documents from the credit proponent till the loan is liquidated to ensure that in case of failure by the client to repay the credit, the bank can auction the land to get back their outstanding dues from the credit defaulter. Majority of the respondents share their sentiment over upholding their land registration documents while availing credit services. FDG indicated that due to collateral requirement and lengthy procedural for credit services did not encourage them to avail credit from the BDBL and other financial institutions.

Respondent #15

"I wanted to establish a backyard dairy farm and a biogas plant in my homestead, but I did not have enough fund. I had to run to different office to get required documents signed and it took me sometime to submit my proposal to the bank (REDCL). It has been almost a year and the fund are yet to be released".

The narrative from the respondent is an indication of difficulty in availing credit accessibility. It takes longer time get credit due to lengthy procedural involved between different institution and at times it is not guaranteed. This has an implication for the aspirant biogas adopters and may discourage them for adopting biogas.

4.2. 3 Extension Services

The table 7 Indicates 76.2 % of the adopters availed the awareness campaign on biogas in contrast to 23.8% non- adopter. The findings from the respondent interviews also indicate that all of them agreed that there are extension services available related to awareness, designing and other technical aspects. This has encouraged them to adopt biogas technology. But they still feel that the technical aspects on maintenance training and refresher course can further capacitated them.

The finding has been corroborated by FGD who agreed that technical support like designing, recommendation of credit monitoring, awareness, and arrangement of spare parts/equipment for biogas plant construction are supported by the extension agent yet there is a delay in replacement of the spare parts due to the absence of agent that deals with the biogas equipment.

The key informant supported that for the whole country, there is a lone dealer for the biogas equipment in Tsirang district. In the process, there is delay in replacement of the equipment during break down of the biogas plant. Such inaccessibility of the equipment can negatively influence biogas adoption. While, in the study area all the biogas plants are functioning well although there was some minor maintenance of plants were done.

4.3 Innovation characteristics affecting biogas adoption

4.3.1 Relative Advantage

From the figure 3, respondents of the biogas adopter, 81.25% believe that biogas has relative advantage over other fuel source as it is cheaper and sustainable source of energy produced in the homestead. 37.5% of the non-users thinks that biogas cannot have relative advantage over other energy source. The biogas user perceive that the technology can be used for at least 20-30 years if managed properly without incurring much cost unlike other energy source that required expenses every time. Faster cooking of meals is achieved comparing to other sources of energy. Besides, those advantages, it is environment user friendly and reduces workload due to reduced frequency of firewood collection from the forest.

The result is supported by the key informants who opined that biogas is a sustainable source of energy and it is expected to function at least for 30-40 years. While the result from the FGD of the non-adopters feel that electricity is a better source of energy for cooking and heating as the recent introduction of 100-unit free electricity subsidy is much cheaper and convenient, unlike biogas which requires continuous care and management. Further, all the non-adopters feel that the firewood from the forest need not have to pay, so they do not see much advantage using biogas.

Respondent # 2

"The work load had reduced with the introduction of the biogas, In the past women and children use to collect firewood at least ten times a month but now we hardly go to forest to collect firewood. The time saved is used for other agriculture work and tendering the children. The children get more time to study and do the home work".

From the above statement, it clearly indicates that there is a relative advantage of using biogas due to reduced work for women and children. However, it was found through the observation that other energy sources like, LPG, kerosene and firewood are still used by the adopters.

4.3.2 Compatibility

Seventy five percent of the biogas adopter respondent have a perception that biogas technology is compatibility to other source of energy for cooking in terms of in terms of intensity of heat and sustainable source of energy (Fig.3). While, 68.75% of the non-adopter respondents are in the perception that biogas is not compatible to other fuel sources.

The result from the FGD revealed that that biogas is compatible to other source of energy and can cooks meals faster than other fuel sources. They indicated that LPG was not accessible at all time and sometimes farmers must return without refuelling LPG after incurring traveling and transportation expenses. Further, the biogas is accessible unlike LPG. However, majority of the biogas respondent feels that there is slight decrease in the gas production during winter seasons. Based on the narration of the non-user, they feel that biogas is not compatible to LPG and firewood as the biogas cannot last more than 5 hours daily and it may not suffice complete cooking of meals.

Respondent # 27

"Before I use biogas, I was worried whether, the biogas has enough heat to cook meals but in reality, it cooks meals much faster than LPG".

The above statement clearly depicts that biogas is compatible to other source of energy in terms of heat generated. This finding has been validated through observation and found out that biogas has better heat intensity to cook meals.

4.3.3 Complexity

Figure 3 illustrate that 62.5 % of the biogas adopters and 75% of the non-adopters perceive that the biogas technology is more complex than other energy sources. The respondents think without good knowledge on the operation modality and management of the plant, things can be very complex and may end up defunct of the technology. However, biogas adopter confirmed that with daily usage of the technology, it built up their confidence on the technology and they do not see much problem on the complexity of the technology.

Respondent # 4

"Initially, we were not confident in the operation of the biogas plant as it looks really complex but with the experience, biogas technology is not really complex".

It can be concluded from the statement that although there is complexity involved to adopt biogas technology but with the experience through practice, it is not that complex.

4.3.4 Observability

The finding from the figure 6 illustrates that 50% of the biogas user and non-adopters perceived that biogas adoption can follow as a result of various observation methods like; fee back and discussion with neighbours, leaning and seeing from the field trips, judgement from the biogas awareness and subsidy and policy support from the government. Most of the respondents stated that the more visible the biogas technology, the higher the chance of adoption areas such visibility can stimulate peer discussion with the friends, neighbour of the adopters. Additionally, they perceived that through observation, it has helped them to develop perceived norms that biogas technology is an alternate energy source for cooking.

The finding has been corroborated by key informants who agree that despite subsidy of €150, they observed that only few farmers have come forward to take away the subsidy to adopt biogas technology.

Respondent # 23

"I have seen some of the biogas constructed by untrained mason never produce a gas. So, I gave away the owning a biogas plant".

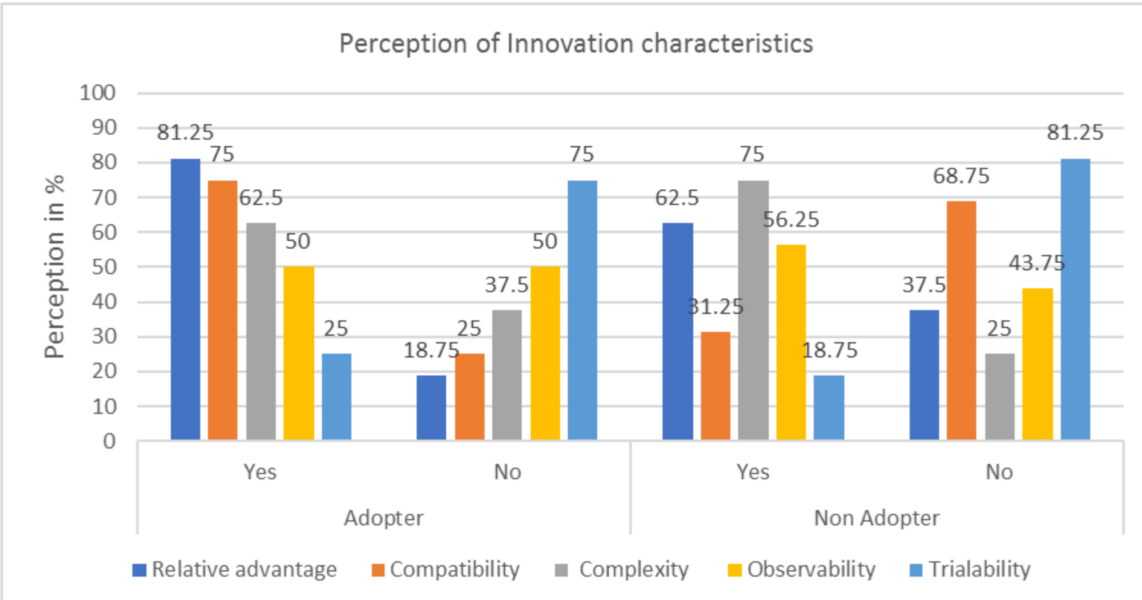
The statement implies that there are few untrained masons who constructed the biogas plant and it never served the purpose. Such practices have discouraged some of the biogas technology aspirant in the study area. This has negatively influenced biogas adoption.

4.3. 5 Trialability

The result depicts from that figure 6 that 81.25% of non- adopters perceive that biogas technology cannot be tried out for a trial and in case of failure of the technology, they may end up into substantial economic loss. While 25% biogas adopters perceive that biogas technology can be tried out as it has been a proven technology and they do not see much risk associated in adoption of the technology.

The result from the FGD indicated that poor household are not able to try out such technology as initial cost of biogas construction is too high to take a risk. Rather, they prefer LPG and electricity instead of biogas.

Figure 3:Innovation characteristics perceptions by respondents



Source: Respondents interview (Dorji, 2019)

4.4 Characteristics of the biogas plants in Shumer block

4.4.1 Size of biogas

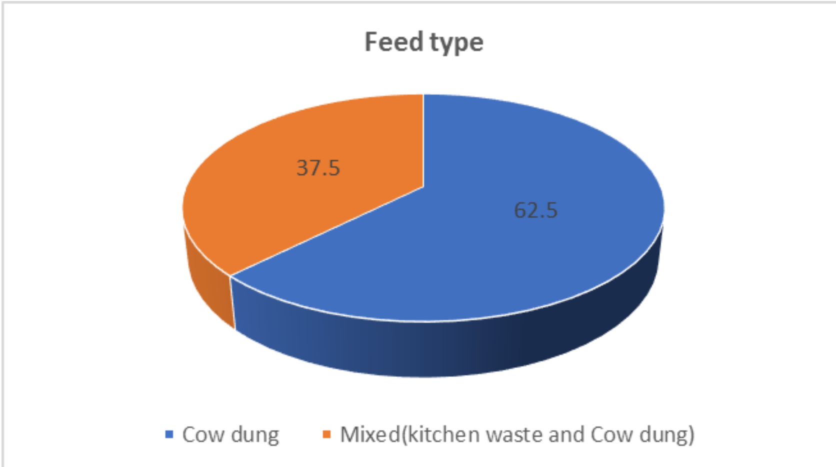
It was found that all the adopter in the study areas owns a 4 cubic metre biogas plant. This finding has been corroborated by the FGD who feels that they can afford and manage this size considering the cost involved for the bigger size biogas plant. The key informants and the FGD corroborated that for the smallholder farmers, this type of biogas size can suffice the cooking of the meals with the average size of 3 to 5 cattle heads per household.

4.4.2 Feed for digester

The result in figure 4 shows that the cow dung was the main source of feed for the digester (62.5 %), while both cow dung and kitchen waste were used by 37.5% of the biogas adopter. The biogas is mainly used for cooking and fertilizer while it was found that the average dung used daily is 22.26 kg in the study area. It was found that biogas adopters had more cow dung production

Availability of cow dung is an essential factor that determine the adoption of biogas was stressed during focused group discussion and key informant interview where it was indicated that the cow dung is the main source of feed for the digester. Observation from the researcher saw that the dung was collected twice daily, and food waste were used as a substrate for the biogas digester.

Figure 4:Feed used for digester



Source: Respondents interview (Dorji, 2019)

4.4.3 Construction cost

It was found that the average construction cost of the 4 cubic metre biogas plant was € 443.91. The finding has been corroborated in FGD and key informant who concur that the cost of household size biogas construction may come to €428.57 to €521.82. Informal conversation with the some of the non-respondent's villager came to know that the technology is only meant for rich people and not for the poor ones. The finding has been corroborated by key informants who agreed that the initial cost of the construction is high but after the establishment, minimum expenditure is incurred while using biogas for energy source for cooking if well managed. It was estimated that annual maintenance cost was lesser than € 20 both by FGD and key informants. The FGD also stressed that the low - income section of the people cannot afford the technology due to initial high investment of the biogas plant. They reported that digging hole for dome construction was tedious work (see cover page and figure 5) and was one of the reasons that many of the people do not want to adopt.

Figure 5:Feeding the digester with dung and Biogas

plant construction

Source: Dorji (2019)

4.5 Farm characteristics that influence the adoption of biogas

4.5.1 Breed & herd size

In the study area, the average herd sizes of biogas adopter were 4.9 heads while that of non-adopter was on average 3.2 heads (table 6) with all respondents owning only jersey cattle. The dung production was found to be 30.1 kg and 16.7 kg for biogas adopter and non-users respectively. The result clearly indicate that the biogas adopters have larger herd size and higher dung production that positively influence adoption of the biogas technology. Both the user and the non-user owns Jersey cattle which has been either introduced by the government either through artificial insemination or natural insemination.

The finding is corroborated by the key informants who indicated that the farmers of the study area are no more interested in indigenous breed of cattle considering that the jersey cattle produce more milk and dung. While, the FGD indicated that the shift from indigenous cattle to improved cattle is due to the existence of Dairy farmers group which encourage to produce more milk.

Table 8: Breed &herd size

Variable		**Adopters**	**Non-Adopters**
Herd Size	Average number of cattle	4.9	3.2
Breed Type	Jersey	100%	100%
Dung production	Average daily production	30.1 kg	16.7 kg

Source: Respondents interview (Dorji, 2019)

4.5.2 Feeding System

The result in table 9 indicated that 63.6% biogas adopter practice stall feeding with none of the adopters practise open grazing. While, 36.4% of the non-adopters use stall feeding followed by 66.7 % stall feeding combined with open grazing. It was found that 4 non-respondents still follow open grazing feeding system. It was found through observation that majority of the biogas has an improved cattle housing which have cemented flooring. This helped the farmers to ease the dung collection in contrast to the non-adopters who used dried leaves as a bedding for the animals. This could be the reasons that the Non-users are not able to meet the dung requirement in case if they must adopt biogas. Moreover, due to open grazing, it may also lead to under collection of the dung. The key informants supported the finding that most of the farmers are supported with cattle housing materials to encourage stall feeding and ease the dung collection for biogas promotion in the district. It was found that the government support on material incentives for shed construction has encouraged biogas adoption in Shumer block.

Table 9:Feeding system

Feeding system	**Adopter**		**Non- Adopter**		**Total**	
	Abs.	%	**Abs.**	%	**Abs.**	%
Open grazing	0	0	4	100	4	100
Stall feeding	14	63.6	8	36.4	22	100
Both	2	33.3	4	66.7	6	100
Total	16		16		32	

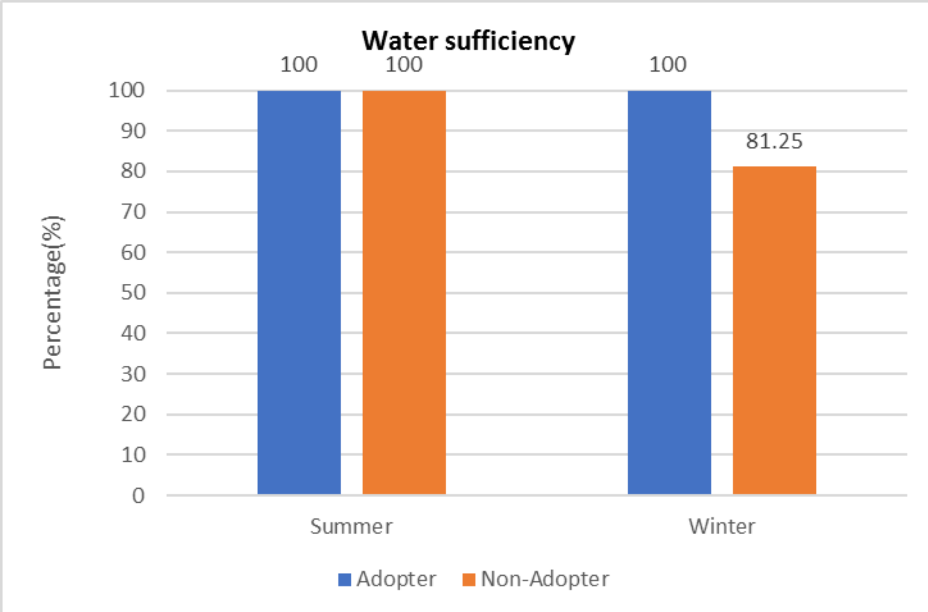
Source: Respondents interview (Dorji, 2019)

4.5.3 Water availability

The result in figure 6 shows that there is 100% water sufficiency during summer for both adopters and non-adopters. While, 18.75% non-user respondents face acute water shortages during winter in contrast to users who has enough water for biogas. Through observation, it was found in the study area that the respondents have stored water in big jerry cans during the study period in July months.

The finding was corroborated in FDG without abundant water, it will be very difficult to adopt biogas while key informants stated that the dung should be mixed in equal ratio with water.

Figure 6:Water availability



Source: Respondents interview (Dorji, 2019)

4.6 Farmers characteristics that influence the adoption of biogas

4.6.1 Household Size

The table 10 indicated that 70.6% adopters and 29.4%non-adopters had more than 5 household members. The average household size of the study area was 4.9 for the biogas user while the non-user has 4.0. It was found that the biogas user has more labour and was found that the relative larger household size adopts biogas technology in the study area.

This finding is corroborated by focused group discussion who pointed out that larger household size has more labour required for construction of the biogas plant. Further, they pointed out that more labour availability in the household has reduced the construction cost and eventually encouraged biogas adoption. The finding is also validated with the key informants that the initial high cost on construction of biogas plant also hinder biogas adoption rate in the study area.

Table 10:Household Size

Household size	Adopter		Non-adopter		Total	
	Abs.	%	Abs.	%	Abs.	%
More than 5	12	70.6	5	29.4	17	100.0
Less than 5	4	26.7	11	73.3	15	100.0
Total	16		16		32	

Source: Respondents interview (Dorji, 2019)

4.6.2 Household head gender

The finding in table 11 indicate that 53.8% male headed, and 47.4% female headed adopted biogas. The result also shows that 52.6% of the non-adopter's respondents were female headed household in contrast to 46.2% male headed household. This shows that male headed household are more likely to adopt biogas technology in the study area.

The focussed group discussion validated the finding that the male headed household are likely to adopt biogas adoption as men are usually the ones who take the household decisions. It was also found out that usually men are the ones who availed the advocacy program on biogas unlike women who spent their time on looking after the household chores.

Table 11:Household head gender

Household head	Adopter		Non-adopter		Total	
	Abs.	**%**	**Abs.**	**%**	**Abs.**	**%**
Male headed	7	53.8	6	46.2	13	100.0
Female headed	9	47.4	10	52.6	19	100.0
Total	16		16		32	

Source: Respondents interview (Dorji, 2019)

4.6.3 Household income

The table 12 illustrates that all the biogas adopters' monthly income was more than € 90 with majority income group falls in between € 91-103. The result also showed that majority of the non-adopter income was below € 90. It implies that the biogas adopters had higher income than the non-adopter. Moreover, the result found that the average monthly income of the biogas adopters was €122 in contrast to non – adopters with € 90.8.

Respondent # 9

"I always wanted to own a biogas plant, but my income was too less to afford it, I hardly earn €85 monthly from sale of livestock products and the cost of biogas plant is quite high".

This statement indicates that there are people interested in biogas technology, but they cannot afford it due to high initial cost of construction as majority of the non-users have income lower than € 90. The above statement is indication of the respondent having low income despite interest to adopt biogas technology. As the biogas installation cost is very high, the respondent dream cannot be materialized unless some other subsidy packages are design for pro-poor farmers. The focused group discussion highlighted that although they realised the benefit of biogas technology, yet, their low income limits them from adoption. The FGD members showed their sentiment by stating that the biogas technology cannot be owned by low income group.

Table 12:Household Income of the respondents

Monthly income (€)	Adopter		Non-adopter		Total	
	Abs.	**%**	**Abs.**	**%**	**Abs.**	**%**
64-77	0	0.0	5	100	5	100
78-90	0	0.0	6	100	6	100
91-103	7	87.5	1	12.5	8	100
104-116	2	50.0	2	50	4	100
117-128	2	66.7	1	33.3	3	100
>128	5	83.3	1	16.7	6	100
Total	16		16		32	

Source: Respondents interview (Dorji, 2019)

4.6.4 Age of the household head

It was found that 75% of the biogas adoption happens in the age range between 30 to 49 years and then the adoption decreases after 50 years (Table 13). with the increase in age of the of the household head, the technology adoption increases in the study area.

The younger participants during the focussed group discussion thinks that the technology should be left to the elderly people while they opt energy from electricity to lighting and cooking. Further the young people indicated they were discouraged by the dirty and time-consuming process of mixing dung with water. They do not want to adopt biogas as electricity was found to be better energy choice for cooking meals and heating. The 100 -unit electricity subsidy by the government has made the electricity much cheaper. Such subsidy in the energy source has negatively influence adoption of the biogas program.

Table 13:Age of household head

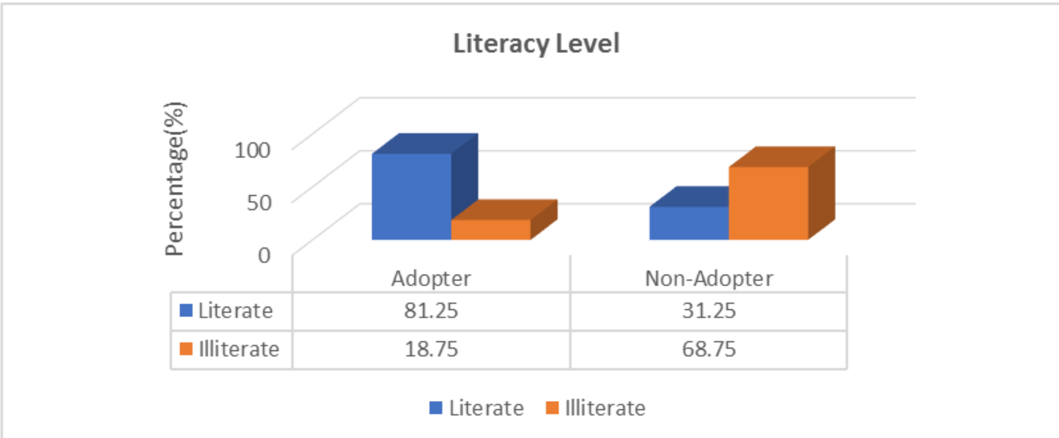
Age range	Adopter		Non- Adopter		Total	
	Abs.	%		%	Abs	%
20 -34	1	16.7	5	83.3	6	100
35-49	12	75	4	25.0	16	100
> 50	3	30	7	70.0	10	100
Total	16		16		32	

Source: Respondents interview (Dorji, 2019)

4.6.5 Education

Figure 7 indicates that 81.25% of the biogas user are literate in contrast to 31.25% non-user. The biogas adopters have either attended formal or non-formal education which helps them to understand about the technology, ultimately leading to adoption. This finding has been validated during FGD that majority of the biogas adopter are educated, and they are able to understand the benefits of the biogas from the advocacy program on biogas which made them easier to convince on the technology. The key informants stated that educated people are easier to convince on the technology and eventually adoption follows.

Figure 7:Literacy rate



Source: Respondents interview (Dorji, 2019)

4.6.6 Land holding

The table 14 indicated that 69.6% biogas adopters own more than 1acre land in contrast to non-adopter with 30.4%. Yet, it clearly indicates that 9 out of 16 non- adopters had land lesser than 1 acre in the study area. Similar views were opined by non-adopter members during FGD that as a result of less land, they prioritise their limited land by investing on an income generating incomes like food crops and cash crops activities. They expressed that biogas plant cannot have an economic return for meeting the basic needs of the households. While, the biogas adopter during the FDG highlighted that the land cannot be a limiting factor as even in a small area of land, the technology can be introduced as after completion of the biogas construction, the land can be restored by covering up the land and eventually, agricultural crops can be grown above the biogas plant.

Table 14:land holding of the respondents

Land size grouping	**Adopter**		**Non-User**		**Total**	
	Abs.	%	**Abs.**	%	**Abs.**	%
<1Acre	0	0	9	100	9	100
>1 Acre	16	69.6	7	30.4	23	100
Total	16		16		32	

Source: Respondents interview (Dorji, 2019)

CHAPTER 5: DISCUSSION

This chapter describes about the discussions on the findings from chapter four. The section 5.1 discuss on the Institutional characteristic, innovation characteristics (5.2), characteristics of biogas (5.3), Farm characteristics (5.4) and characteristics of farmers (5.5) that influence adoption of biogas. The section 5.6 describe on the critical reflection as a researcher. The finding has been compared with other researchers and conclusion are drawn eventually.

5.1 Institutional characteristics affecting biogas adoption

From the section 4.2.1 that although there is subsidy support from the government for the biogas adopters of €150 which has helped to bring down the cost of construction of biogas plant and eventually motivated to adopt biogas technology. A study carried out by Sun et al. (2014) in rural China opined that the adoption of the biogas increased with subsidy policy in place. A similar finding was reported in China that with the immediate down - sizing of the subsidy, biogas adoption rate dropped (Rajendran, et al., 2012). However, Bhattarai, et al.(2018) reported that despite Nepal starting subsidy program on biogas technology in the 1970s, the program was not geographically targeted to poor and only 5 % of subsidy-eligible households have adopted biogas. The upfront installation cost is high and has limited the low income from adopting biogas technology. This finding corelate the finding of Bansal, et al., (2013), who found that the initial installation cost of biogas plant was much higher than the monthly spending of low-income section of households in rural communities. This makes it difficult to afford biogas plant even after receiving the capital subsidy for the low-income households in rural areas. That could be reason despite government providing subsidy, there are only few people availing it. Low income household argue that subsidy does not make any difference as they cannot afford to construct a biogas plant even with the subsidy provided. Ghimire (2013) reported that there should be a national policy which can attracts more companies to participate in the biogas development. This can address the accessibility of spare parts and equipment at any time as currently the whole country has a lone dealer on biogas which is three days distance by car from the study area.

The finding in section 4.2.2 indicates that despite having credit facilities in place, accessibility has been not easy for the respondents. It involved lengthy procedural and delay in release of the fund. Delay in the release of the fund further does not favour farmers to avail credit services and negatively influence biogas adoption. That's the reason that aspiring adopters are discouraged as their movement incur expenses and time. Collateral requirement was not favouring the low-income group while upholding land registration certificate till the liquidation of loan can be sentimental to farmers. Such progressions cannot encourage to avail credit services. The biogas adopter's managed to avail credit services due to higher income and subsequently, the adoption of biogas occurs in contrast to non-users who are not able to benefit from the credit services due to the lengthy procedure involved. The finding concurs with Bansal, et al. (2013) who identified that procedural delays in getting financial support as one of the barriers of biogas adoption in rural communities. This finding corelate Lewis and van der Ban (2004) who found that favourable to credit positively biogas adoption. Kelebe, et al.(2017) indicated that access to credit positively affect biogas adoption decision of households. Improved adoption of biogas due to credit accessibility in Northern Ethiopia has been reported too (Mengistu , et al., 2016). Both farmers and financial institutions are not in favour of processing the credit for biogas as it does not generate cash return to repay the loan (Bajgain, 2008). Eventually, this can also negatively influence biogas adoption as without credit services, the poor section of people cannot afford to adopt biogas technology.

From the section 4.2.3, it indicates that there are extension services available related to awareness, designing and other technical aspects. Such presence of extension services can encourage them to adopt biogas technology. While, they still feel that the technical aspects on maintenance training and refresher course can further capacitated them. While most of the non- adopters**-** expressed that they did not avail awareness and training related to biogas. Such limited advocacy and training and inadequate follow-up services can be a barriers to adoption of the biogas was also identified as the key barriers (Rupf et al., 2015)**.** The study carried out in Pakistan reveal that awareness regarding the pros and cons of using biogas were positively influencing the adoption of a biogas system in the area (Jan & Akram, 2018). The finding has been corroborated by FGD who agreed that technical support like designing, recommendation of credit monitoring, awareness, and arrangement of spare parts/equipment for biogas plant construction are supported by the extensionist and community technician yet there is a delay in replacement of the spare parts due to the absence of agent that deals with the biogas equipment during the break down. The key informant supported that for the whole country, there is a lone dealer for the biogas equipment in Tsirang district. In the process, there is delay in replacement of the equipment during break down of the biogas plant.

5.2 Innovation characteristics affecting biogas adoption

As indicated in section 4.3.1, there is the perception by the biogas adopters using biogas is cheaper and sustainable source of energy that can be produced in homestead although initial investment is expensive. However, Gulbrandsen (2011, p, 50) found that it takes them two and half years to earn back the investment money. While, Samar et al., (2016, p. 20) reported that for the investment on the construction of 4m^3 India takes thirty-eight months to recover the investment from the biogas plant. He further reported that €138.46 is saved annually by replacing LPG with biogas. This implies that means that biogas is a cheaper alternative to the traditional fuels in the long run, and this as a reason to invest on this technology. This indicates that biogas has a relative advantage over kerosene, firewood and LPG. Rogers (1995) emphasize this as one of the main elements in getting a successful diffusion of biogas. The technology can be used for at least longer duration if managed properly without incurring much cost unlike other energy source that required expenses every time. Faster cooking of meals is achieved comparing to other sources of energy. Besides, those advantages, it is environment user friendly and reduces workload due to reduced frequency of firewood collection from the forest. Wahyudi (2017) reported that the relative advantage of biogas is the most essential factor to speed up the biogas adoption rate.

All biogas user responded that biogas technology is compatibility in terms of intensity of heat to cook the meals as indicated in section 4.3.2. It cooks meals faster than LPG and time can be save due to faster cooking. Further, the biogas is accessible unlike LPG and the shortage of two cylinders every month per household even after importing 1,000MT of non-subsidised LPG from India has been reported (Kuensel, 2019). This indicates that LPG is not accessible every time which makes biogas a better fuel for cooking. Slight decrease in the gas production during winter seasons could be due to the low temperature and as a result of low temperature, the fermentation is slower and results to decrease in biogas production. Low biogas production which is insufficient for cooking during the winter season has been reported by Kaniyamparambil (2011) as cited by Mittal, et al. (2018) has forced the biogas users to switch to other fuels. Similar finding on low output of biogas for two - three months in winter has been reported (Rupf et al., 2015)**.**

From the section 4.3.3, there was a mixed feeling over the complexity of biogas adoption. Most of the non-users feel that biogas technology is difficult to use it and it needs good knowledge on the operation modality, management, However, the users found with daily usage of the technology, it built up their confidence of the technology and they do not see much problem on the complexity of the technology. As indicated that the degree to which an innovation is perceived as difficult to understand and use (Rogers, 1995, p. 242), the ideas which are simple are more likely to adopt rapidly unlike the innovation which needs to develop skills and understanding. While, it is understood that technical skills are not required to use firewood as a means of fuel for cooking, but you need technical skills to operate the biogas. This also negative influence adoption of biogas.

As reflected in section 4.3.4, observation played crucial role in the adoption of the biogas. Through observation from neighbours, awareness from the District Livestock Sector, subsidy and policy support from the government. While non-users feel that through observation, the initial cost of construction of the biogas plant is very expensive and labour intensive that does not encourage to adopt biogas. Put (1998) ascribed that the relative advantages are more obvious, more clearly visible, occur rather immediately after adoption (short-term character) and this has also positively influenced biogas. The potential biogas adopters could observe the advantage of the biogas and eventually adoption followed.

The biogas technology cannot be tried out for a trial and in case of failure of the technology, they may end up into substantial economic loss considering the huge initial cost involved for construction as pointed out in the section 4.3.5. As a result of not able to trial out, this could be reasons why the wider adoption is possible within short time. The barriers like lack of structure, lack of opportunities to trial out these substitute energy resources, and resistance to change. Even if there are intentions to adopt or at least a desire to try out new innovations, environmental constraints such as a lack of resources or infrastructure will inhibit the process (Yzer, 2012). This finding concurs with Rogers (1995) who states that the degree to which an innovation may be investigated or tried out within limited time. The innovations that are trailable by learning by doing can be eventually adopted quicker than the innovations that cannot be available. As such, biogas technology is not triable, potential adopters must rely on the information on the adopters or someone should convince. If the potential adopters are not convinced, it is likely that the potential adopters may not adopt it.

5.3 Characteristics of the biogas plants in Shumer block

All biogas users owned 4 cubic metre household size biogas plant as it is the smallest size proposed by the government of Bhutan for subsidy support package based on section 4.4.1. The cost has been considered by the government to enable the aspiring biogas adopters to adopt the biogas plant with minimum expenses. The bigger size biogas plants are usually adopted by the high-income farmers and government farms. This finding is in line to the report of Bajgain (2008, p 10), who reported that Bhutanese smallholder farmers usually adopt Deenbandu type-fixed dome digester/Chinese dome of $4m^3$ and $6m^3$ capacity. The study in Nepal found that 4 and 6 m^3 sizes biogas plants requires 36 kg of dung to burn a stove for 3.5 hours in the hilly areas (Bajgain and Shakya, 2005). Similarly, the findings of Surendra, et al. (2014) reported that the most common size of biogas digester in developing countries ranges from 2 -$10m^3$ size as they limit to lighting and cooking. However, it was found that $4m^3$ size was found more beneficial to small farmers than large farmers (Abbas, et al., 2017). This concludes that, the small size biogas plants are mostly adopted by the small holder farmers. Currently, the bigger sized biogas plants are adopted in institutions and the government owned livestock farms. With more benefits, observed from the use of biogas plant, farmers may adopt bigger size plant. However, it is still expensive for poor and low-income group of farmers to invest on biogas plant despite assured subsidy.

Based on the result in section 4.4.2, the main feed for the digester is cow dung while both cow dung and kitchen waste are also used in the study area. The cow dung is used due to availability in the homestead and is socially accepted by the society. This finding concurs to the study conducted by Mittal, et al.(2018) who reported that the agricultural wastes and livestock manure are primarily used as feedstocks in household biogas digesters by the small household. Similar finding was reported that the social in acceptance for biogas from substrates like night soil, human excreta, dead animal carcass (Rupf, et al., 2015).

From the section 4.4.3, the respondent appreciated the benefits of biogas for cooking and fertilizer but feels that the initial cost on biogas construction is too high with the average estimate of €443.91. This finding is similar to Samar et al., (2016, P.18) who estimated that the cost of construction of 4 m^3 biogas plant in India was € 475.64. As a result of high initial costs of biogas plant construction, it did not encourage low income group to adopt biogas despite their interest on the technology. Most of the respondents have monthly income lower than € 90 and biogas adoption was not found as a priority at this moment. Their income must distribute towards the expenses of the children education and meeting basic needs of the households. Similar finding by Surendra, et al.(2014) reported that the high installation costs are the major barriers for wider adoption of biogas. Thus, low income group of people are not able to adopt biogas despite their interest over the technology in the study area. For the low-income group of respondent, firewood and electricity is a preferred source of the energy. For wider adoption of biogas for the lower income group, some packages should come up as biogas is renewable energy source and environment friendly energy source for cooking and lighting.

5.4 Farm characteristics influencing the adoption of biogas

As indicated in section 4.5.1, both the adopter and the non-adopter owns jersey cattle which has been either introduced by the government either through artificial insemination and natural insemination. Such presence of jersey cattle can produce more dung than the indigenous cattle. As a result of a greater number of cattle, it can encourage the households to adopt biogas. Cow dung being the main source of substrate to feed the digester can be garner from the presence of large number of cattle. The finding is in line to findings were reported in Bangladesh by Kabir, et al.(2013) that it is likely to increase adoption of biogas with the increase in cattle heads. Similar finding was reported in Uganda that, Male headed household positively influence biogas adoption (Walekhwa, et al., 2010). The finding concurs with the study carried out by Bajgain (2008) who reported that Bhutanese households prefer to rear more hybrid cattle like jersey rather than ordinary cattle which eventually can produce more dung. Similar findings were reported in the focussed group discussion (FGD) and key informant that jersey cattle produces more milk and dung in contrast to indigenous cattle. The study area has potential to produce enough dung for biogas adoption due to presence of hybrid cattle like jersey breed. Moreover, it can be narrated that the households with larger herd size has adopted the biogas technology in the study area.

The majority of the respondent's practices stall feeding that eases dung collection beside having a potentiality to accumulate more dung as a substrate for the digester as indicated in the section 4.5.2. However, open grazing and mixed practice of open grazing combined with stall feeding is still prevalent in the non-user respondents farm. Such practices can trigger in losing the substantial quantity of dung during the open grazing period. This can lead to under collection of dung and can hinder the biogas adoption. Similar findings were reported by Mittal, et al.(2018) that the under collection of dung was as a result of cattle roaming freely in the field. Due to insufficient dung may eventually result in improper functioning of the biogas plant. FAO(2018) reported that shed keeping or stall feeding has an advantage over the free-range grazing that the dung can be easily collected, stored, or composted and applied to the crops. Similarly, Bajgain(2008) based on the study done in Bhutan highlighted that through stall feeding the availability of dung can be increased to 8 kg from 6 kg daily. The findings are in line to Walekhwa, et al.(2010) who posits that free-range system of rearing cattle could significantly affect the availability of dung for production of biogas and eventually influencing the construction of the digester. Thus, stall feeding can be practiced to fully collect the dung from the cattle and at least three cattle are required to produce 20 – 25 kg of dung required for household biogas plant. The support for the cattle sheds can also ease in dung collection which was observed in the study area.

The section 4.5.3 it is understood that there is water scarcity during winter months in the study area and it could have been the reason that they don't have enough water to mix with the dung and eventually reducing the gas production in the winter. Moreover, the animals need enough water in the feed to produce more dung that is crucial for the generating optimum level of gas. This finding is like the study done in India by Samar, et al. (2016) who reported that large volume of water requirement in dry and drought-prone areas is one of the reasons for the low uptake of biogas technologies. Similar findings were opined by Surendra et al. (2014), who posits that water and waste should be mixed in an equal ratio for the successful production of biogas by the bio- digester. Since it is very crucial for equal mixing ratio of dung is to water, without water, the biogas plant may not function well and ultimately lead to defunct and incur huge loss to the farmers. In this process, the scarcity of the water may also negatively influence biogas adoption.

5.5 Farmers characteristics that influence the adoption of biogas

It was found from the section 4.6.1 that the relative larger household size adopted biogas technology in the study area. The average household size was 4.87 for the biogas user while the non-user has four. The adoption of biogas by the user was due to larger family size which indicate that more labour can inspire the household to adopt biogas. The study done by Kelebe, et al.(2017) reported that larger household size has are likely to adopt biogas technology. Similar finding was reported by Wang, et al.(2011) that presence of excess labour encouraged households to adopt biogas. The study by Kabir, et al. (2013) found that larger family has more working members and thus more labour available for maintenance activities while it enables for routine biogas operation and eventually influence positively on biogas adoption. Bond & Templeton, (2011) also reported that biogas plants need enough labour for operation and maintenance. However, Nepal, et al.(2011) disagreed with the above findings and argued that the households with more members can negatively influence over adopting clean fuel as they have more labour force for the collection of firewood. Similar findings have been supported by Kabir, et al., (2013) that larger households could also use their family members to other income-generating activities due to the dependency on insufficient family resource. This may also negatively influence biogas adoption. It may be concluded that larger household size has higher chances of biogas adoption compare to the smaller households' size.

The result in section 4.6.2 shows that male headed household adopted more biogas than female headed in the study area. This finding is substantiated by the FGD that household head gender plays an important role for adoption of the biogas. Similar finding was reported in Uganda that, male headed household positively influence biogas adoption (Walekhwa, et al., 2010). Similar finding was also reported that the male-headed households are more likely to adopt the technology than female-headed household given their authourity to influence adoption of the biogas technology (Mengistu, et al., 2016; Wawa,2012). This implies that men are very influential than the women and eventually, they uphold the decision making in the household. Since the men usually are involved in off farm activities, they are the ones who earn income for the family. Therefore, it depends on him whether to invest their earning in the household for adoption of bio the technology or not. Moreover, men are usually the ones who are involved in attending meeting, training and awareness campaign as most of their participation requires to decide on certain issues which women usually cannot do alone. While, women are also engaged in daily household chores which keeps them home and they are not able to benefit from those advocacy program like biogas. Such process does not favour women to make decision. Through such meeting, it is likely that the man gets more opportunities to understand on the benefits of the technology such as biogas and eventually adoption follows. Conversely, Kelebe, et al.(2017) found that female headed household positively influence adoption of the biogas as they are directly involved in the energy requirement for cooking and heating.

It was found from the section 4.6.3 that the biogas non-user respondents have monthly income lesser than the biogas users and the biogas adoption was adopted mostly by wealthy farmers. The non-biogas adopter felt that low level of income limits them from biogas adoption as the technology adoption require huge investment of €443.91. The finding concurs to Rahut, et al.(2016) who reported that that wealthier farmers adopt biogas bio gas in Bhutan. Similar finding was reported in Uganda that, household with higher income positively influence biogas adoption (Walekhwa, et al., 2010).

Due to the initial high installation cost involved in biogas plant, the low income-households cannot afford biogas plant despite receiving the capital subsidy (Bansal, et al., 2013). Further, the lesser income section of the households must limit from adoption of biogas technology as they prioritise other household expenses to meet the basic needs like child education, food and clothing. The energy requirement can be done with other energy sources like electricity and firewood which is accessible too. However, Iqbal, et al.(2013, P. 576) reported that the although the adoption of biogas increase with the income level yet, it was found that at certain point that the highest income group have lesser chances of adoption. This could be the fact that the rich section of the people has a liberty to make choice over other energy sources like LPG, electricity and solar energy. The low income of the respondents that is lesser than €89.74 was one of the barriers for biogas adoption in the study area.

In section 4.6.4, with the increase age in the household the technology adoption is likely to increases as the young people are still not financially stable and may not have enough saving to invest on biogas. Their priorities will be mainly for construction of houses and providing education to the children which may not influence them over biogas adoption. In contrary, older people would have enough saving and are ready for investment in the technology. Similar findings were reported that the possibility of adopting biogas will increase with the age (Iqbal, et al., 2013). While, Wawa (2012) reported that the younger people assume that holding cow-dung may contract with skin diseases. During the focused group discussion, the younger participants emphasised that the technology suits well with old people but not them. They were discouraged to see people mixing cow dung with water by their bare hand which they felt was unhygienic. Electricity was a preferred choice of energy source for the non-adopters and young respondents. This could be due to the youngsters who are familiar with the electricity operation modalities feel more comfortable using it rather than biogas which needs daily feeding of dung and water.

The biogas users have either attended formal or non-formal education while majority of the non-user have not (section 4.6.5). Without literacy many of the non-user respondents cannot internalize and understand the technical terms during the awareness and training of biogas advocacy program conducted by District Livestock Sector. Such barrier can affect their ability in adoption of the technology like biogas and may ignore the technology immediately without giving second thought.

The finding were inaccordance to Kelebe, et al.(2017) who reported that the level of education positively influences adoption of the biogas. The finding harmonises with that of study conducted by Fabiyu(2015) who reported that low levels of education is a barrier to technology adoption as a result to limited access to knowledge. Similar finding was reported by Lewis and van der Ban (2004) who states that education can positively affect the adoption of innovation. Dendup and Arimura (2019) also indicated with access to information approximately 39% of Bhutanese households are more likely to adopt clean cooking fuel while, 49% of households are less likely to adopt dirty fuel like firewood. It can be concluded that education positively influence adoption of biogas in the study area.

From the section 4.6.6, biogas adopters have comparatively more land holding size than the non-adopters. The findings corelate to Gulbrandsen (2011) who postulates that larger sizes of land of the household, more adoption of the biogas technology as contrast to households with smaller sizes of land in Tanzania. The implication of these findings is that with the more holding sizes, they have privilege to make choice for farming unlike those respondents who have lesser land must limit to agricultural production as they have limited space for agriculture activities such as vegetables, planting food or cash crops. The finding is like those of Iqbal, et al. (2013) who found that people with more land have one -third times more likely to adopt the biogas. This clearly shows that there was a positive association between adoption of the biogas and the landholdings.

5.6. Critical Reflection

My position as Livestock production Officer might have influenced in obtaining the information from the study area. As I am very familiar to the study area, they might have shared me the information to please me rather than the ground reality. On the other hand, I felt that due to my closeness with the people of the study area, they did not hesitate to share the ground reality As I result, I believe, the information is generated at the best. While, incentives provided to them in the form of refreshment and allowances may have also positively influence the finding. However, I told the respondents to voice out the ground reality as it can help in revamping of the biogas policy framework.

While conducting the research work in my field, the conceptual framework was found very useful as it guided me to align my objectives, framing research questions and to prepares interview questionnaires deemed for collection. It further guided me to outline all the procedure right from the introduction section till the conclusion and recommendation. This conceptual frame work guided me to follow up the activities that will eventually help to answer the research questions, while it helped me to fulfill the goal of the study at the same time. Without the conceptual framework, I could not have come up with this report. Initial I did not have exact idea on the exact role of the conceptual framework, but I understood at the end of the study that it was like a driver of car, who can lead you to your destiny. I believe without conceptual frame work; the researcher will not have clear direction to do the research and may end up writing unwanted and omitting required information. In the coming years, this is going to be useful to write other research works.

The study limits to one block although there are 11 blocks in the district. The purposive sampling size might also left out some of the potential respondents who could have shared different views and might have impact on the finding of the study. The data collection period fall during the harvesting time of maize and the respondent were in haste as my study was not of their priority. In this process, some of the respondent were not able to dedicate their time to share the information. Realising this, I changed my strategies by visiting them in the evening hours. This proved to be helpful to obtain in-depth information from the respondents.

Focus group discussion was enriching as it helped me to cross check the individual responses and findings with them. I had two focus group, one with non-adopter and another with adopter. I felt I should have done a mixed group of non-adopter and adopter to understand on their stand on the pertaining issues. I felt having separate FGD can generate bias result. I should have organized joint FGD instead of separate FGD with adopters and non-adopters. The closeness with the key informants might also helped me to generate required information and in validating the data with the individual respondent findings and FGD.

Feedback from my supervisor was very critical and it confused me at times when he shared his neutral opinion, but it was realized that I was not thinking out of box. Realising it, I took my own decision to adapt to the feedbacks as it help me learn more dependently. There was fear at times whether am I doing in right way. In fact, it helped to broaden my knowledge. His timely support has enabled to complete my report on time. There were times when supervisor was providing valuable feedbacks and upon incorporating the change, the paper set up got distorted. I felt it was extra work for me. But at the end, the changes were meaningful, and it strengthened the research quality. Eventually, I was confident enough to do my research by own

The important limitation in this study could be explored in future research as my study focus only on factors effecting biogas adoption. For a country like Bhutan with different geo-ecological conditions, further research is needed to identify alternative biogas technologies such as flexi-biogas to bring down the costs of investment in biogas technology for the benefit of poor

The finding of this result will help relevant institutions to put stronger intervention on the gaps that will help to wider dissemination of the household biogas technology to the poor section of the people. This can be done through conducive policy framework reforms to develop sustainable strategy for promoting wider use of biogas among potential user.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

This section 6.1 describes about the conclusion from the study area on the factor influencing adoption of biogas in Shumer block under Pemagatshel. The conclusion answers the sub main question. While, section 6.2 suggest applied recommendation for wider dissemination of biogas technology in the study area.

6.1 Conclusion

To answer the main question, "What are the factors affecting the adoption of household size biogas technology among farmers in Shumer, Pemagatshel?"; the following findings are summarised:

6.1.1 Innovation characteristics influencing adoption of biogas

The innovation characteristics like relative advantage and compatibility were driving factors for adoption of biogas by the adopters comparing to LPG and firewood as a sustainable source of energy. while, using biogas was not perceived to be complex. However, the non-users perceived that using electricity and firewood is much cheaper considering their low level of income source refrain them from adoption of biogas plants.

6.1.2 Institutional characteristics affecting biogas adoption

The institutional characteristics like perceived low subsidy, limited awareness, electricity subsidy, and credit inaccessibility due to lack of collateral accompanied by lengthy credit procedural were major factors that influence negatively adoption of household biogas technology. Absence of biogas agent in the district was impeding the biogas user during the break down of the plant. It was evident that 100-unit electricity subsidy was enough to meet the cooking and lighting of the house that has impeded biogas adoption.

6.1.3 Characteristics of the biogas plants

It was found that all the adopter in the study areas owns a 4 cubic metre biogas plant. the cow dung was the main source of feed for the digester, while both cow dung and kitchen waste were used. The average construction cost of the 4 cubic metre biogas plant was € 443.91. It was evident that the respondents have a perception that the poor section of people cannot afford to adopt biogas technology. Both the biogas adopters and non-adopters perceived that the high upfront installation cost of the biogas plants was the major barrier for adoption of the biogas for the low-income group.

6.1.4 Farm characteristics that influence the adoption of biogas

It was revealed that farm characteristics like herd size, water availability, stall feeding positively influence adoption of the household biogas technology. It was evident that with the larger herd size, the dung requirement could be met. While stall feeding helped to ease the dung collection besides avoiding dung loss from open grazing.

6.1.5 Farmers characteristics that influence the adoption of biogas

The farmers characteristics like herd size, literacy, household size, size of land holding, average household monthly income, stall feeding positively influence the adoption. While, male headed household has adopted more biogas than the female headed household. The decrease in the gas production during the winter is explained by use of LPG during the winter seasons to meet the energy for cooking. The work contributes by providing knowledge on those factors which needs to be addressed by the government to increase wider adoption of biogas technology through change or adopting of policies. Such intervention will go a long way in addressing environmental and health problems besides reduced workload for the women and children through biogas adoption thereby enhancing sustainable development by developing countries.

6.2 Applied Recommendations

One of the main findings of the study was that credit inaccessibility and high investment on biogas plant construction were barrier for biogas adoption. Hence it is recommended to the DLS (DoL) to trap the potentials of biogas, conducive policy framework reforms to develop sustainable strategy for promoting wider use of biogas among potential user as follow:

1. The government is suggested to revamp the existing subsidy packages. This can be done through providing minimum subsidy of 50% for general public and separate subsidy package with at least 80% for pro-poor farmers.
2. Difficulty to access credits without collaterals and loan for process documentation is seen as one of the hurdles for the low-income households. A policy strategy, such as developing soft loan with lower interest rates (4-8%), tailor made loan scheme for the poor, shortening of documentation procedural at the community levels would immensely benefit the disadvantage groups and low - income households. This program can be implemented at the end of January 2020 in close collaboration with financial institution, local government and Bhutan Biogas Project.
3. The District consider instituting one biogas agent at farmers shop in Pemagatshel town by January 2020 to expediate the supply of spare parts and equipment. Such arrangement can help in resolving the current issues on the delay in replacement of spare parts and equipment for biogas.

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APPENDICES

Annexure 1: Interview Checklists

Semi -structure interview for biogas users and Non-users (32 respondents)

What are the characteristics of the biogas plants in Shumer block?

Social, economic and democratic characteristics of respondents (gender, age, education, income, number of animals per household and household size)

Type of biogas plant – different design of biogas plant available

Biogas plant size

Cost of biogas construction

Feed for biogas digester

Source of finance for biogas installation

What are the farmers characteristics that influence the adoption of biogas?

Livestock holding, cattle breeds, farming system etc.

No. of farm labour

Literacy

Head of the household

Gender of the household

Accessibility to LPG gas and firewood

Utilization of biogas plant

Knowledge, attitude and practices about biogas plant – reasons for non-adoption

What are the farm characteristics that influence the adoption of biogas?

Availability of Water

Feeding system of the cattle (open grazing or stall feeding)

Availability of land

Availability of dung

Breed & herd size

Dung is production and sufficiency to feed the digester

What are institutional characteristics affecting biogas adoption?

Provision of financial incentive from government, project, financial institutions etc.

Technical support of government, project etc.

Active attendances of other government institutions – which stakeholders play a role in the biogas production sector.

What is the innovative characteristic which influence biogas adoption?

Relative Advantage

Compatibility

Trialability

Observability

Complexity

Topic list for Key informants (4 key informants)

What are the characteristics of the biogas plants?

Type of biogas plant – different design of biogas plant available

Biogas plant size

Feed used for digester

Source of finance for biogas installation

What are farmers and their farm characteristics that influence the adoption of biogas?

Livestock holding, cattle breeds, farming system etc.

No. of farm labour

Accessibility to LPG gas

Utilization of biogas plant

Water accessibility

Knowledge, attitude and practices about biogas plant – reasons for non-adoption

What are institutional characteristics affecting biogas adoption?

Provision of financial incentive from government, project, financial institutions etc.

Technical support of government, project etc.

Active attendances of other government institutions – which stakeholders play a role in the biogas production sector.

What is the innovation characteristic that influences biogas adoptions?

Relative Advantages, Compatibility

Trialability and Observability

Focus Group Discussion (2 numbers, 1 user & 1 Non-user)

Opinion on results/findings of key informants' interviews on adoption and non-adoption of biogas plant

Main challenges on adopting biogas plant.

Readiness of farmers on adoption of biogas plant.

Credit accessibility

Household decision to adopt biogas adoption

Barriers of biogas adoption

Subsidy packages

Effect of literacy in biogas adoption

Way forward for adoption of biogas plant

Annexure 2 : Research Plan

Activities	Months (2019)						Remarks
	Apr	May	June	Jul	Aug	Sep	
Discussion on Research topic with guide teacher and supervisor							
Submission of the first draft Project proposal to Supervisor							
Submission of the 2nd draft proposal to Supervisor							
Final submission of the proposal							9th June 2019
Materials collection							
Data collection							June 3rd week to mid-Aug
Compilation of data							
Discussion of the finding and results with Supervisor							
Dissertation write -up							
1st draft submission							
2nd draft submission							
Final Thesis submission							11th Sept 2019