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Designing a Biogas Promotion Model in Iran's Villages (Application of Grounded Theory)

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Abstract

Energy sustainability, especially in agriculture, has been considered according to increasing population and lack of fossil fuel resources for future generations. Therefore, extension of renewable energies, including biogas, is essential for sustainable development. Therefore, this research has been designed and implemented to determine how to extend biogas in rural places of Iran. The present study is a qualitative research and uses the principles of the grounded theory as a guide to data collection and analysis and the presentation of the model. The sample included experts from the Ministry of Agriculture and Renewable Energy Organization of Iran who were selected by purposive sampling. Field observations and interviews were used to collect data. Data analysis was performed using the coding process (open, axial and selective coding). Thus analyzing the responses, 10 core categories was extracted that presented as intervening conditions, contextual conditions and strategies and based on them a paradigmatic model was designed to extend biogas in rural places of Iran. Finally, based on the findings of the study, suggestions were presented to accelerate the process.

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Introduction

Sustainable energy is one of the dimensions of sustainable development in the present century. Sustainable energy means continuous supply of energy for today's needs without compromising the ability of future generations to meet their needs (Sakakibara et al., 2014). According to the Energy Agency, global energy demand will increase 36% between 2008 and 2035 (Papzan and Papzan, 2012). To achieve sustainability goals should go towards sustainable energy technologies, due to the limited fossil energy resources and their destructive effects on nature (Shafie et al., 2020). Sustainable technologies include renewable energy sources such as hydroelectric power, solar energy, wind energy, geothermal energy, artificial photogenic and wave energy, and technologies designed to improve energy efficiency. Therefore, dual energy pillars include energy efficiency and renewable energy (Sakakibara et al., 2014).

One of the things that should be considered in energy sustainability is the environmental pollution caused by energy consumption. To achieve sustainability in natural energy resources

low-carbon strategy is needed that would require a significant increase in renewable energy production. Biogas is a clean energy. Produced biogas is directly used to produce electricity and heat (Pavicic et al, 2022). Many studies showed that biogas is a clean energy because it decrease Co_2 emissions and successfully remove H_2S (Teddei and Ptit, 2021, Lee et al., 2020 and Kapoor et al., 2019). According to the World Health Organization, 92% of the world's population is affected by air pollution, and 6.5 million people died in 2012 due to air pollution. This means that 11 percent of deaths are air pollution (WHO, 2016). Air pollution is one of the main environmental problems in Iran. According to the World Health Organization, more than 26,000 people die in Iran annually due to air pollution and Iran is ranked 16th in the world (WHO, 2016). According to statistics, among 146 countries, Iran is at position 132 based on environmental sustainability (Environmental Sustainability Index (ESI)), and the 114 stands in the index of environmental performance (Environmental Performance Index (EPI)) (Papzan and Papzan 2012). On the other hand, fueling the remote villages is difficult and costly even in a country like Iran, which has high energy resources. Also, Iranian ranchers who are the main livestock in the country often do not have access to energy and the elimination of livestock manure is one of their problems, as these contaminants, in addition to polluting the environment, lead to Ozone layer perforation. Most countries in the world have made massive plans to supply their energy through renewable energies. Biogas is derived from the anaerobic fermentation method of the biomass. The main resources for biogas are production, animal waste, urban sewage and industrial waste and agricultural waste. Biogas is a gaseous product of anaerobic digestion and a biological process in which microorganisms turn into small bioactive elements in the absence of oxygen (Chrebet and Martinka, 2012). In the assessment of biogas, this energy is also referred to as a clean and renewable energy (Morero et al., 2015). Biogas is a clean fuel that does not cause environmental pollution at the same time, the risk of a biogas explosion is low (Otim et al., 2012). The use of biogas as a low-carbon element and renewable energy source in Europe is steadily increasing (Ravina and Genan, 2015). Among the European countries, Germany is far superior in producing biogas from the rest. In 2010, the German biogas production was approximately 5800 large site that have about 2,300 megawatts of electricity. While the United States has 160 biogas sites, of which they produce about 57.1 megawatts of electricity (Bramley et al., 2011). In the same year, the total production of European biogas was 9/10 (Mtoe), of which Germany's share was 61% and England with the share of 16.5% second (Van Foreest, 2012). China with almost seven million biogas systems has first rank on the world and in this way saving fossil fuels much. Biogas has been exploited in many countries around the world, including India, Nepal, Japan, China, and the United States. In most countries of the world, the

construction and operation of biogas units is being done in the form of rural cooperatives. India and China are the pioneers of biogas technology in the world (Alizadeh, 2007). Developed countries have consistently emphasized large-scale biogas for the production of heat and energy, while developing countries focus on small-scale biogas production to provide primary heating cooking (REN 21, 2013). Iran's consumption of energy per capita is higher than the consumption of the world per capita (Iran Energy Efficiency Organization, 2015). With increasing population, lack of access to energy in remote villages and lack of fossil fuels for future generations, energy sustainability is a challenge to be addressed especially in the agricultural sector. In this section, the extension of biogas in rural areas can help ranchers to provide energy from livestock residues. Therefore, the purpose of this research is to answer the general question "How can biogas be extended in rural areas of Iran?"

Review of literature

In the case of biogas generation in rural areas, internal and external investigations have been carried out, including:

Bahrami (2017) said that biogas could be a good alternative to fossil fuels in the rural areas and it is justifiable economically, socially and environmentally. Therefore biogas needs to be localized in rural areas. Also, research on the production of biogas from livestock and rural waste products in Kurdistan province showed that annual production of 11.272 billion m^3 of biogas could be achieved. It also has great environmental benefits and would be a viable building could save up to 17.4% to 39.4% of the energy consumption of rural households (Adeli Gilani et al., 2014).

In Germany studies have shown that, the potential for biogas production from waste and animal residue in villages is about 24-23 billion cubic meters (Poeschl et al., 2010). In Nigeria, research estimates stated that the country could produce about 1.26 billion cubic meters of biogas per year, which could control carbon dioxide emissions to 6,683 tonnes a year (Adeoti et al., 2014). In Malaysia, in 2012, about 4589.49 million cubic meters of biogas was available from available animal residue, which could generate 109.27 kw/h electricity (Abdshahian et al., 2016). In Poland, biogas production from agricultural waste significantly increased from 36.65 million cubic meters in 2011 to 37.99 million cubic meters in 2014 (Piwowar et al., 2016). Research in Ethiopia compares villagers using biogas with those who do not use it and its results showed that confident biogas, means having skilled design and correct construction, is very useful to people and welcomed (Mengistu et al., 2016). Ethiopians started implementing household biogas programs in villages to reduce the household energy problem and their environmental, social and economic challenges (EREDPC, 2008). The production of biogas from animal residue and agricultural waste, in addition to solving the problem of excessive consumption of fossil fuels and

the recycling of residue and waste, creates a fertilizer that maintains soil from erosion and flood and evaporation and converts waste and residue into organic fertilizers and, consequently, animal feed (EREDPC, 2008; Amigun et al., 2012). Poisoning caused by low efficiency of fossil fuels is a problem in the world, that the production of biogas from animal waste or plant waste has resolved it and raised the productivity to 60%in China and 57% in India (Khandelwal and Gupta, 2009). Zhang and his colleagues, in their article, point out the benefits of biogas and the potential for its use in the villages of China and ultimately advised biogas production, at the small and large levels in the rural areas, in terms of environmental and economic development (Zhang et al., 2015). Wang and his colleagues in their research argued that supportive policies could partly reduce villagers' biogas production costs and lead to the creation and development of rural biogas (Wang et al, 2016). Renewable energy projects such as household biogas are not economically feasible without financial facilities (Wang et al., 2013 and Hill et al., 2006). China's emphasis on biogas production and support the launch of its home sites because biogas compensates for the limited access of villages to energy. In addition, biogas is a clean and environmentally friendly energy with advanced technology (Jiang et al., 2011). Chinese researchers said that despite government support of 50 percent, biogas was generally accepted by middle and upper-middle income farmers (Fan et al., 2011; Zuo, 2012 and Qiu et al., 2013). Studies in China showed that although household biogas programs experienced a rapid development and a significant extent, reducing their use may disrupt this process in the future (Wang et al., 2013). According to available research, the development of household biogas is affected by agricultural waste supplies, the number of manpower, the proportion of the distance of the place of residence, household income and the wishes of the residents Which directly affects the economy and convenience of the biogas use and its equipment (Li et al., 2015; Qu et al., 2013). Reports also showed that only 19 - 30% of the biogas production potential was used in the villages of China (Qu et al., 2013; Cui, 2009; Chen et al., 2010).

A study in the United States to assess the environmental, economic and technical aspects of rural biogas diggers Stated that plastic tanks, compared to fixed tanks, can be constructed and developed more and less costly and are more environmentally friendly. In 2007, NGO did projects related to the construction of biogas tanks in the villages of Latin America's, Their main objective was to improve the quality of life of villagers by replacing clean fuel with fossil fuels. They also aimed to preserve the environment by reducing greenhouse gases and reduce the costs of the villagers for fuel and fertilizer and reduce the pressure of work and a waste of time for women and children in order to gather wood for the fire (Garfí et al., 2012).

In the past three decades, Bangladesh faces a serious energy crisis (shortages of electricity and gas), especially in rural areas. These areas, with the use of wood and damage to the environment, seek to compensate for the situation, although they are not successful. So, to prevent the destruction of nature and to preserve the environment and achieve sustainable development, the government has sought to push them towards clean renewable energies (Khan and Andrew, 2016). There are widespread views that adequate, clean and affordable energy for the villagers is necessary for eradicating poverty, improving human well-being and raising standards of living worldwide (Lin and Juan, 2008). Therefore, biogas technology is an important activity to handle the rising energy demand of rural areas in developing countries (Purohit and Kandpal, 2007).

Method

The study was a qualitative research and the principles of grounded theory used and as a guide to collecting and analyzing data and planning model. Grounded Theory is a research in the field (Bazargan, 2017). Qualitative research is a comprehensive and explorative approach. Approach to study seeks to describe and analyze the social world culture and human behavior from the perspective of the self-study (Williams, 2007, Azizi and Zamani, 2014). Since qualitative research is the way to achieve mental content and cannot be done through routines and accurate quantitative (DiCicco-Bloom and Crabtree, 2006), research Sampling was purposeful to be able to reach saturation about main issue. The logic and power of choosing the participants in the sense that selected samples provide the most information based on the research question (Holloway and Galvin, 2016). In other words, the selection of research units or samples is based on the purpose of the research. The study sample consisted of 38 experts from the Ministry of Agriculture and Renewable Energy Organization which was selected purposefully. In qualitative research, key methods are used for data collection including: participation in research, direct observation, in-depth interview, examination of documents. But the grounded theory is based mainly on interviews and textual data (Ghaderzadeh et al., 2013). In this study in-depth interview with the research community was method of data analysis for grounded theory. Of course, direct observation, participant observation, grouping discussions, library and Internet research documents were used as a supplementary method. In grounded theory, the theory is based on the basic concepts derived from the data and these concepts are key elements of analysis. Because the theory is obtained from the data conceptualization not from the sum of objective data (Bazargan, 2017). The stages of grounded theory (Hariri, 2011) are: theoretical sampling, data collection, coding and analysis of data that begins at the same time and continue to theoretical saturation stage. In the theoretical saturation stage, a model or theory is constructed. After the construction of the theory, its reliability must be assured. So that research sample confirms the theory or

model. Open coding involves the process of breaking interviews, observations, and other forms of data into distinct semantic units and identifying key words and phrases. Axial coding has brought out concepts through the dynamic relationships between them, and should provide a basis for theory building (Goulding, 2002). Axial coding is process related to the classes with their subcategories. The focus of axial coding is to create a model that identifies the specific conditions that phenomenon occur in. Selective coding is based on open and axial encoding results. It involves the process of selecting the main class and linking it with the other classes systematically and validating it, and filling the class that needs further improvement (Brown et al., 2002). The main class is, in fact, the same as the main phenomenon that other classes gather around it and the whole form universe (Glaser and Strauss, 1967). Determining validity and reliability in qualitative research is different from quantitative research. Therefore, the validity of the research was determined through triangulation by gathering evidence from different sources as well as controlling external judges and stated that the findings and interpretation is supported by the data. Research reliability was accomplished through emphasis on model transferability and review of findings by participants.

Results and Discussion

At first, the concepts extracted from the data in open coding, and then the classification of concepts in the axial and selective coding, are presented separately from the discussed topics and the questions asked. Finally, the model will be presented based on the coding results. The findings from the interviews were categorized in the form of answers to some general questions. The questions in the interviews included five categories:

- Why biogas should be extended in rural areas of Iran?
- What resources and conditions exist to extend biogas in rural areas of Iran?
- What are the problems with the extension of biogas in rural areas of Iran?
- How biogas can be extended in rural areas of Iran?
- What will be the benefits or consequences of extending biogas in rural areas of Iran?

Initially, based on a semi-structured interview, the initial research question was raised. Then it was discussed around it and answered other questions to achieve the research goal. The interviews were recorded and the notes were written and coded. 95 items were extracted as open coding out of all the interviews. In the next step, these codes were categorized and open codes encoded in 31 categories as axial codes. Finally, the axial codes were coded in the form of 10 selective codes. The following tables based on the separation conditions have been reported. The

concepts outlined in Table (1) represent the intervening conditions; table (2), the contextual conditions, and Table (3) represent the research strategies.

As shown in Table (1), sustainable development, inadequate energy consumption, human resources in the village and the ease of biogas training are intervening conditions in the phenomenon of biogas extension in rural areas. Each of these factors has subsets, including sustainable development, which can be effective on biogas extension in three dimensions: social, economic, and environmental. In fact lack of gas in rural area is one of the reasons for the rural people migration to cities. This social problem can be solved slightly, with biogas extension in rural areas. In past studies, sustainable development has been emphasized in three dimensions. Sustainable development based on three principles of social, economic, and environmental sustainability, and providing solutions to issues such as the destruction of natural resources, the destruction of biological systems, climate change, the excessive population growth, inequity and the decline of quality of life by answering today's human needs, it can bring at least the same conditions to today's world for the future (Adeli Gilani et al., 2014).

Table 1: Expression of intervening conditions in open, axial and selective coding

Open coding	Axial coding	selective coding
The lack of gas in many villages has caused the villagers to migrate to the city. The evacuation of villages is one of the problems caused by lack of gas. As villagers migrate to the city, the number of ranchers and, consequently, the number of livestock decreased. Some villages are vacant in the winter due to lack of gas and have seasonal residents.	**Social sustainability**	**Sustainable Development**
Supply gas to remote villages is not economical. Due to water scarcity and climate change, livestock production is one of the alternative ways of farming that needs to be given more attention. Animal waste disposal costs for farmers.	**Economic sustainability**	
Increasing the amount of carbon from the burning of fossil fuels such as wood and oil effects. Maintaining resources for future generations so that they can have minimum conditions. Air pollution has increased due to the use of energy sources and pollutants.	**Environmental sustainability**	
A lot of energy is wasted in Iran due to incorrect use. Iran has the first place in Middle East gas consumption.	**Wasted energy**	**Improper energy consumption**
Fossil energy sources are limited and non-renewable. Rangelands are also sources of fuel that are very vulnerable.	**Reducing energy reserves**	
One of the sources of energy in some villages is wood, which destroys forests. Burning thorns and shrubs in rural areas will destroy the rangeland.	**The loss of rangelands and forests**	

In many villages, especially remote villages there are no job for young people. Traditional livestock does not require much workforce and usually needs one or two ranchers.	**Unemployment**	**Providing Human Resources in rural areas**
Many rural youth do not have any special education or expertise. Rural youth are not interested in staying in the village and doing their fathers work.	**Lack of expertise among youth**	
In Iran, unlike many countries, there are young labor forces in rural areas. Human resources are needed to run biogas in animal husbandry.	**A huge of labor force in rural areas**	
Training of the biogas plant maintenance is very easy and inexpensive. After initial installation, it does not require any expertise to operate the biogas plant.	**Training cost**	**Ease of training**
Training set up and operate the biogas machine is possible in a short time. The training time of biogas can be very flexible.	**Training time**	
Biogas is a very simple technology. Training setup and use of biogas requires no special facilities. Biogas training does not require any special place or conditions. A lot of people can be trained in an animal husbandry that has biogas.	**Training facilities**	

One of the principles of studying a phenomenon with the help of grounded theory is to consider the conditions in which the phenomenon occurs. In Table (2), considering this case, the contextual conditions of the phenomenon are stated. In this study, the contextual problems and barriers are expressed in two categories: controllable and uncontrollable. Technical barriers, economic barriers, social barriers and personal barriers are in the category of controllable contextual barriers and natural barriers, safety barriers and environmental barriers are uncontrollable barriers. Experts pointed to these barriers and said that in order to biogas extension in rural areas should pay attention to these conditions in different regions.

Table 2: Explain the contextual conditions of the research in open, axial and selective coding

Open coding	Axial coding	selective coding
The biogas plant requires an experienced engineer to launch. Working with a biogas plant is initially difficult for a simple rancher. In the event of non-compliance with the safety principles, there is a potential for explosion in an anaerobic fermentation tank. If there is clogging in the pipelines, there is a possibility of gas returning to the device and explosion. The location of the tanks and their depth on the ground and their coverage depends on the regions. Installing the compressor is essential to maintain the pressure of the tanks.	**Technical barriers**	**controllable barriers**
The initial cost of biogas setup is heavy for ranchers. The price of gas cylinders and oil in rural areas is cheap and ranchers need to pay a lower cost.	**Economic barriers**	

The price of energy resources in Iran is low relative to the whole world. Launching biogas in livestock requires space and facilities. There is administrative bureaucracy for fund of the implementation of the new project.		
Most villagers have little participation in educational programs in rural areas. Ranchers usually have their own information sources and do not consult the extension agents. In the rural areas, counseling and collective works become much diminished. Villagers often resist change. Most ranchers still believe in the traditional way and deny new methods. Most villagers have fateful spirit and it barriers to accept innovation. Most villagers and ranchers believe that they will not benefit from government. Lack of confidence in the state system prevents the adoption of proposed innovations from the government.	**Social barriers**	
People have a lower level of literacy and knowledge about technology; they have the greater fear. Who has more motivation will be more successful in implementing technology. Rural people are not usually pursuing new technologies. People who work harder and have more activities in programs are more successful. People who are risky and innovators adopt innovative more. Innovators are generally more successful in implementing and exploiting new technologies. Initially working with biogas seems hard for ranchers. Ranchers are afraid of working with the biogas, due to low awareness.	**Personal Barriers**	
Biogas plant has low performance in cold weather. In the warm hours of the day, the performance of biogas plant is greater. Remote villages, especially those who are in mountainous areas, have harsh ways. Gas distribution to some villages is very difficult and sometimes impossible because of road conditions.	**Natural barriers**	**Uncontrollable barriers**
In most villages, gas cylinders are used as a source of thermal energy, which is very dangerous. The possibility of a gas cylinder explosion with the slightest error in consumption. Annual Statistics show a lot of gas poisoning due to the use of oil or gas cylinder. Firewood and gas cylinder are fuels that produce bad smoke and cause pollution and respiratory problems. Biogas is much safer and cleaner compared to the gas cylinder.	**Safety barriers**	
Soot from firewood and gas cylinders cause pollution. In some livestock farms, the location of the biogas system is far from the livestock.	**Environmental barriers**	

Strategies in this research are in fact decisions that have not yet been implemented, but if implemented, they can realize the phenomenon that is the biogas extension in rural areas. As outlined in Table (3), government policies, infrastructure, technical management, and foresight

are the proposed strategies for this study. Of course, in previous studies, the importance of some of these strategies has been emphasized. Including: An investigation in China has highlighted the factors influencing the development of biogas by the government's incentives, which is very effective on the decision of biogas production operators (Qu et al., 2013). It is also argued that the laws, regulations and policies on biogas development are the factors contributing to its extension (Chen et al., 2010; Jiang, 2011; Feng, 2012).

Table 3: Expression of research strategies in open, axial and selective coding

Open coding	Axial coding	selective coding
Create government incentives to extend biogas in rural areas. Introduce and encourage successful people in biogas using.	**encouragers**	Government policy
Provide loans and facilities to applicants for the implementation of biogas. Supporting interior financier to launch tanks manufacturing companies. Providing loans to workshops or compressor manufacturing plants to control their product prices.	**Loans and facilities**	
Establishing limitations on the use of fossil fuels for proper management of consumption. Correct pricing of fossil fuels to prevent irregular consumption. Law enforcement and dealing with those who destroy vegetation to provide energy.	**Energy resource management**	
Advertising the use of renewable energy sources, especially biogas in rural areas. Among the leading ranchers and village trustees make culture about the use of biogas. Explain the benefits of biogas and the need of rural biogas extension for village trustees at public meetings or village councils.	**Culture making**	Infrastructure
Make various suitable tanks in terms of size and body shape for different areas. Initial facilities such as compressor and tank required to be produced with various prices. Launching biogas service and support centers in rural areas.	**Support and protect**	
The variety of equipment and facilities is such that people with different income levels can use them. Considering the small space of traditional livestock, tanks should be resized and portable as far as possible. Making lightweight tanks with proper cover of the area.	**Construction**	
The most important step in using biogas is its initial launch, so skilled people are trained to launch biogas. Training people to launch and repair the biogas plant.	**Training Specialist**	Technical management
If necessary, workshops will be created for practical training of users. Arrangements visits for getting familiar with biogas device.	**Practical training**	
Distribute raining packages among people for the maintenance of biogas	**Consultation**	

device and working with it. Give advice to people about biogas benefits and how to work with it.		
Posters are designed to show the energy crisis for rural people. Try to achieve the point that management of energy crisis will be the concern of rural people.	**Enlightenment**	forecasting
The responsibility of people towards the next generation is explained to them. Express problems and pollution of rural areas in future due to the accumulation of residue or burning of smoke material for rural people.	**Forecast of the future**	
Express the role of biogas in preserving water resources and its impact on drought management for rural people. People, especially elder villagers, will be justified in explaining the multi-functionality of biogas. The benefits and advantages of biogas fertilizer in compare with manure be expressed for rural people.	**Justifying Multi functionality of Biogas**	

Paradigm Model for Biogas Extension in Rural Areas of Iran

The paradigm model was used to summarize the results obtained from axial coding and the use of selective coding to present the theory. In the paradigm model, the conditions affecting the phenomenon can include causal, intervening, contextual conditions, or all of these (Hooman, 2015). The result of the analysis of responses is the extraction of 10 nuclear categories, which have been described as "intervening conditions", " contextual conditions" and "strategies" and the following paradigm model has been designed based on them. As in Figure 1 can be seen, in this study the central phenomenon is biogas extension in rural areas of Iran that influenced by causal, intervening and contextual conditions, and suggested strategies for it Which, if implemented, could have good consequences for rural ranchers, Including: reducing air pollution and protecting the environment, creating rural employment and reducing migration, preserving village health, maintaining energy resources and saving oil and fossil fuels. In fact, the production of biogas from animal residue reduces greenhouse gas emissions and also, reduces carbon dioxide emissions, thus reducing air pollution and protecting the environment. Since the biogas system needs human resources to launch and operate therefore, one of the consequences of extending it in the rural areas is to create employment for young people, thereby motivating them to stay in the village and reduce the migration of rural youth to the city. Extension of biogas in rural areas can help conserve the oil and fossil energy. By extending biogas while preserving vegetation, cutting off trees and shrubs, it is also prevented from degrading rangelands to provide fuel for the villagers. By promoting biogas in rural areas, it can replace existing fossil fuels and, in addition to maintaining energy resources and saving oil and fossil fuels, improves the safety of industrial and domestic fuel. Biogas is a clean, high thermal property that can easily replace fossil fuels.

Existing studies on its thermal value have shown that the thermal value of urban gas is 4.07 (Kwh / M) and natural gas is 7.52 (Kwh / M) and biogas 5.96 (Kwh / M) (Bahrami, 2017). Biogas extension in rural areas helps to maintain rural health. Ranchers are saved by turning the waste into biogas, due to odor and pollution and the appearance of bad disasters, and because of the high temperature inside the tanks, the pathogens are eliminated and as a result, common diseases of humans and animals are controlled. In previous studies, it has also been argued that with the entrance of livestock residue into the biogas unit, the factors of common diseases between humans and livestock are largely eliminated (Bahrami, 2017). Liquid from biogas is used as a fertilizer rich in N.P.K and free of pathogenic agents for the cultivation and fungus breeding. Previous studies have also shown that biogas produces organic fertilizers that are the main source of nutrients (N.P.K) and free of weed seeds and pathogens. Because weed seeds in livestock wastes will be disappear during the process of anaerobic fermentation (Bahrami, 2017). Using biogas fertilizer led to soil fertility and increases the yield of products by 10 to 20 percent (Adeli Gilani et al., 2014).

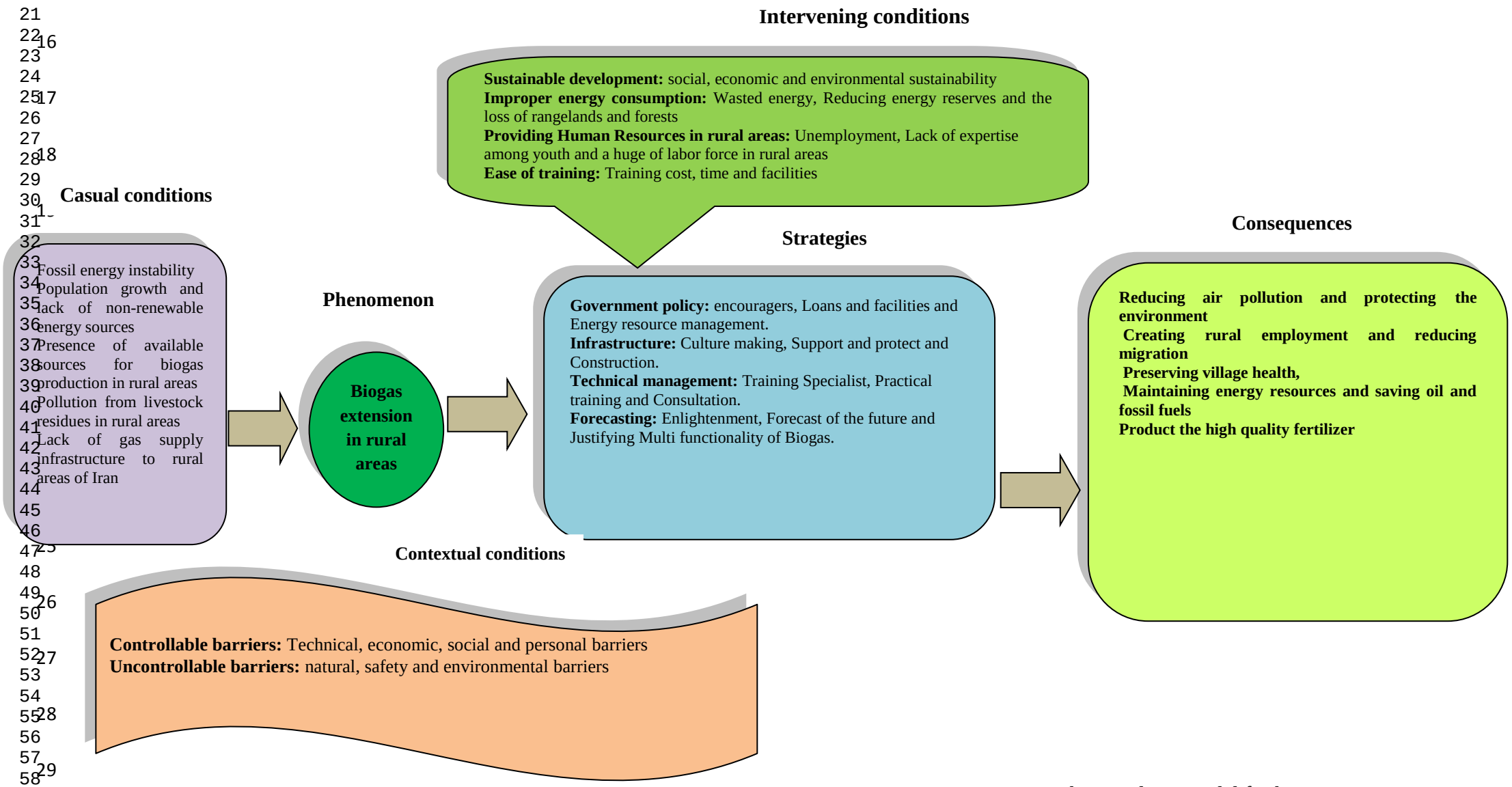

Figure1. The paradigm model for biogas extension in rural areas of Iran

Conclusion

In this research the general question "How biogas can be extended in rural areas of Iran?" was answered by using the grounded theory and presenting a paradigm model of biogas extension in rural areas of Iran. In this paradigm model, all the conditions, barriers, problems, and future horizons are considered. Finally, biogas extension in rural areas of Iran can be done by using this paradigm model. So, with its implementation, it was hoped for the future and the achievement of consequences. According to the experts' opinions and existing experiences, it is suggested that the ranchers are encouraged to set up a collective biogas plant to solve the economic problems, especially in the field of buying compressor for constant gas pressure. By doing so, while aggregating capital and using it in better equipment and production of biogas, everyone is responsible for its maintenance. Finally, it should be noted that agriculture extension has the task of facilitating and implementing the plan in action and it should not only be limited to research results. The proposed model only provides a general framework for activities and can be modified in different regions according to the existing conditions. Also, before biogas extension, the calculated studies should provide a good understanding of the people and the area in which the biogas is to be implemented. Villages have a dynamic social, climatic, economic and cultural system. The smallest change in this system will cause a change in all its dimensions. Having a systematic vision to the village and considering it in the biogas extension program will provide a ground for its comprehensive extension. Therefore, biogas extension should be considered as a comprehensive, decentralized, and participatory implementation for sustainable development. Because renewable energy in the world is a major issue and a major challenge, suggest for the future research to focus on other sources of biogas supply, such as agricultural wastes. Research on the use of other renewable energy sources in the agricultural sector is being carried out.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants performed by any of the authors beyond that which is described in the text.

Participants had informed consent to cooperate in the study.

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